

ATTACHMENT 3

CQA Plan and Technical Specifications

Construction Quality Assurance Plan

Issued for Permit

Virginia Electric and Power Company
Possum Point Power Station
Coal Combustion Residual Surface Impoundment Closures
Dumfries, Virginia

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DominionSM

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1.0 Introduction

This Construction Quality Assurance (CQA) Plan presents the guidelines necessary to provide certification that the Possum Point Power Station Coal Combustion Residual (CCR) Surface Impoundment Closures Project (Project) is constructed in accordance with its approved permit. It addresses inspection and verification activities and procedures necessary to determine and document the quality of key components of the constructed facility. These components include prepared subgrade preparation, geosynthetic cap system construction, drain pipe/trench construction, dam modifications, and final cover system construction.

The closure of the CCRs Surface Impoundment from site preparation through placement of the final cover system will be performed by qualified earthwork contractors.

2.0 Quality Control Responsibilities

At a minimum, the personnel involved in the construction include the Owner/Operator, Project Construction Manager, Quality Control (QC) Team, Owner's Engineer, Contractor, and other Installers. The responsibilities and authority of these personnel are defined in the following sections. A pre-construction conference will be held prior to construction projects to discuss the roles and responsibilities of the parties involved.

2.1 Owner/Operator

The Owner is Virginia Power and Electric Company. The Owner will approve design revisions and administer related permit modifications. The Owner will designate one representative to serve as the Project Construction Manager.

2.2 Project Construction Manager

The Project Construction Manager (PCM) will be a Dominion employee or contractor designated to be the Owner's Representative for pond closures. The PCM will be responsible for management and administration of site construction and QC activities. The PCM's responsibilities include coordinating and managing QC Team activities, coordinating with the Owner's Professional Engineer, and coordinating activities with permitting agencies. The PCM will also:

- Coordinate activities with other contractors and consultants involved with the closure construction of the ponds;
- Approve design changes and submittals, through the Owner's Professional Engineer and QC Team; and
- Approve Change Orders and payment requests.

2.3 QC Team

The QC Team will be a representative of the Owner's Engineer and will include personnel qualified in construction quality assurance/QC and testing procedures pertinent and necessary to pond closure construction. QC Team personnel activities will be coordinated by the PCM or Owner's Engineer. QC Team personnel include any professional or technician necessary to provide Dominion with technical oversight or review of the construction of the facility. QC Team personnel will be familiar with CCR properties and characteristics, as well as functional intent of the design. The QC Team may also be called the CQA Consultant or CQA Personnel in the Technical Specifications.

2.4 Owner's Professional Engineer

The Owner's Professional Engineer (PE) shall be a Professional Engineer licensed in the State of Virginia (VA), who is responsible for certifying the construction of the Project meets the intent of the Construction Documents and other applicable regulatory requirements. The Owner's PE shall:

- Personally conduct random site visits to check on his representative (QC Team), the Contractor, and other elements of construction;
- Personally conduct a final site visit on the completed facilities for certification;
- Approve modifications to QC testing methods as designated herein or as outlined in Project requirements; and
- Be responsible for collection of documentation, review, and approval of submittals, review QC data for conformance with Project requirements, and generation of QC-related reports.

2.5 General Contractor

The General Contractor shall employ a full time QC Manager to:

- Prepare submittals;
- Coordinate with Owner's QC Team to ensure all required testing is being performed in a timely manner;
- Coordinate with Geosynthetics Installer to ensure material QC testing is being performed;
- Coordinate with Surveying Subcontractor to ensure adequate survey data is collected to allow for completion of as-built drawings; and
- Prepare red-line drawings for any changes to contract drawings.

2.6 Geosynthetics Installer

The Contractor's Geosynthetics Installer shall employ a full time QC Representative to ensure the Project geosynthetics (i.e., 40 mil LLDPE geomembrane, Geocomposite Drainage Net [GDN] and geotextiles) are installed and tested in accordance with the specifications. The Geosynthetics QC Representative shall document the geosynthetics installation and testing performed by the Geosynthetics Installer and coordinate with the General Contractor's QC Manager, and the Owner's QC team for conformance testing requirements.

2.7 Surveyor

The Contractor shall hire a surveyor to establish the lines and grades for construction, prepare the record drawings, and verify construction. All surveying shall be performed under the direct supervision of a Professional Licensed Surveyor. All survey results shall be certified by a VA registered professional land surveyor.

3.0 Soil Liner and Underdrain

3.1 Low Permeability Soil Liner

A portion of the existing Low Permeability Soil Liner under Surface Impoundment D may require removal during ash regrading activities. The liner will be re-established with a new 12-inch-thick liner of low permeability clay. Density testing and geotechnical sampling will be performed. Shelby Tube Sampling will be performed to confirm permeability requirements. All ongoing activities will be monitored daily by the QC Team.

3.1.1 Material

The material used to repair and replace the low permeability soil liner shall be free of unsuitable material, contaminated material, CCRs, cobbles, and boulders, and shall have a minimum permeability of 1×10^{-7} centimeters/second. In-place and source material testing requirements are summarized in Tables 12 and 13 attached to this report.

3.1.2 Construction

Low permeability soil liner placement and compaction control shall conform to the following requirements:

- ▶ The 12-inch low permeability soil layer shall be placed in two or more lifts.
- ▶ Compaction control testing shall be conducted on the 12-inch soil layer at a minimum frequency of three in-place density tests per acre per lift of soil layer, with at least three tests performed each day that cover is placed.

3.1.3 Test Pad

A minimum 50-foot by 50-foot test pad shall be constructed for every source of low permeability soil or soil type to demonstrate the ability of the soil to be used as a low permeability soil liner material. The test pad shall establish the range of compaction, moisture content, Unified Soil Classification System (USCS) classification, and grain size requirements that can be expected to achieve the low permeability liner requirements. The test pads shall be correlated with grain size analysis, liquid and plastic limits, moisture content, relative compaction, remolded permeability, and undisturbed Shelby Tube sample permeability.

Test pads may also be constructed following Geosynthetic Research Institute (GRI) GS11 to assess the potential for geomembrane puncture and to evaluate the need for a cushion geotextile.

3.2 Underdrain

Furnish and install underdrain geotextile, drainage aggregate and perforated high density polyethylene (HDPE) pipe in underdrains beneath the geosynthetic cap system as required to discharge CCR drainage during and after construction. Subsurface dewatering water, which is collected by any underdrain system, shall be pumped to the water treatment system to be installed in Surface Impoundment E. After the geosynthetic cap system is installed, the underdrains may continue to operate as a passive dewatering system. Once the underdrains have dried up due to sufficient dewatering of the CCR in the surface impoundment, the underdrains should be capped in place.

3.2.1 Geotextile Material

The hybrid monolithic woven-nonwoven needle-punched underdrain geotextile meeting the requirements of Table 10. Qualified materials shall be the top (hybrid) geotextile from CoalDrain 300 mil Geocomposite, as manufactured by GSE or equal as approved by the Owner's Representative.

- ▶ Geotextile Delivery, Handling, and Storage: Shall comply with Section 5.1.3;
- ▶ Geotextile Conformance Sampling and Testing: Table 10; and
- ▶ Geotextile Handling and Placement: Underdrain geotextile shall be placed in pond ash, **with the nonwoven side of the hybrid geotextile placed against the ash**. Underdrain geotextile shall be installed at locations necessary for construction dewatering and approved by the Owner's Representative. Continuously overlap underdrain geotextile panels a minimum of 18 inches across

the top of the trench and a minimum of three feet for end-to-end panels. All placement of underdrain geotextile and associated aggregate and piping shall be observed by the CQA Consultant. Underdrain geotextile installation shall be approved by the CQA Consultant prior to installation of the associated underdrain aggregate and piping.

3.2.2 Underdrain Pipe

- ▶ Underdrain pipe shall comply with Section 6.2.

3.2.3 Underdrain Aggregate

- ▶ Underdrain aggregate shall comply with Section 6.3.

4.0 Geosynthetic Clay Liner

Geosynthetic Clay Liner (GCL) may be installed over the existing low permeability bottom liner on the exposed side slopes of the existing pond. Surfaces that are to receive GCL shall be prepared in accordance with the contract drawings and specifications. The GCL Installer shall install GCL only on surfaces that have been approved in writing.

4.1 Material

Prior to, or coincident with, the shipment of the GCL to the Project site, the Owner's Representative shall review and approve submittals from the GCL Manufacturer, which shall include:

- GCL Manufacturer's GCL specification sheet(s); and
- GCL Manufacturer's Quality Control (MQC) Certificates.

4.2 Delivery, Handling, and Storage

All geotextile delivery, handling, and unloading shall be performed in the presence of the Owner's Representative. During unloading, the Contractor and Owner's Representative shall conduct an inspection of all delivered geotextile for defects and damage caused by inadequate or improper packaging, shipping, unloading, or handling. GCL having defects or damage shall be examined by the Owner's Representative to determine its acceptability.

Wrappings protecting GCL rolls shall be removed less than one hour prior to unrolling the GCL. The GCL shall not be exposed to sunlight for more than 15 days, unless otherwise specified or guaranteed by the GCL Manufacturer.

4.3 Conformance Sampling and Testing

Conformance sampling and testing of the GCL shall be performed by the Owner's Representative in accordance with the minimum sampling frequencies outlined in Table 4 of this CQA Plan. Conformance testing will be completed according to the following procedure:

- Cut a sample per manufacturer's recommendation. Do not include the first 3 feet of the roll. Mark the samples with an arrow indicating the machine direction of the geotextile.
- Label the sample and include all pertinent project and geotextile product information.
- Complete chain-of-custody and testing request forms and forward conformance samples to the Geosynthetics CQA Laboratory.

The Owner's Representative shall review results from all conformance testing to verify compliance with requirements. If all requirements are met, the Owner's Representative shall issue written acceptance of the GCL for deployment. If the requirements are not met, the Owner's Representative shall notify the Contractor and either resample/retest the failed roll/panel or mark the failed roll/panel as rejected. If

the failed roll/panel is rejected, the Owner's Representative shall obtain conformance samples from the closest numerical roll/panel on each side of the failed roll/panel number. The two additional GCL samples must conform to Table 4 (included in this CQA Plan) for the applicable GCL. If either sample fails, the two numerically closest untested rolls on both sides of the failed sample will be tested by the Geosynthetics CQA Laboratory. These 10 samples must conform to the specifications. If any of these samples fail, every roll of GCL on-site and every subsequently delivered roll that is from the same supplier must be tested by the Geosynthetics CQA Laboratory for conformance.

5.0 Geosynthetic Cap System Construction

A multi-component geosynthetic cap system will be installed directly over the prepared subgrade. The geosynthetic cap system will consist of the following components from top to bottom:

- ▶ Drain GDN Layer with non-woven geotextile heat-bonded to both sides;
- ▶ Textured 40 mil Linear Low Density Polyethylene (LLDPE) Geomembrane; and
- ▶ Six ounces per square yard non-woven geotextile (Cushion Geotextile).

5.1 Cushion Geotextile

5.1.1 Cushion Geotextile

The cushion geotextile prevents damage to the LLDPE geomembrane from the prepared subgrade soil materials. The cushion geotextile will be 12 ounces per square yard (oz./sq.yd.) nonwoven, needle-punched geotextile installation, made up of polypropylene filaments. All geotextile installation activities will be monitored on a daily basis by the Owner's Representative and QC Team. The Owner's PE shall personally conduct random inspections to check on his representative, the contractor, and other elements of construction.

5.1.2 Material

Prior to, or coincident with, the shipment of the geotextile to the project site, the Owner's Representative shall review and approve submittals from the Geotextile Manufacturer, which shall include:

- ▶ Geotextile Manufacturer's geotextile specification sheet(s); and
- ▶ Geotextile Manufacturer's MQC Certificates.

5.1.3 Delivery, Handling, and Storage

All geotextile delivery, handling, and unloading shall be performed in the presence of the Owner's Representative. During unloading, the Contractor and Owner's Representative shall conduct an inspection of all delivered geotextile for defects and damage caused by inadequate or improper packaging, shipping, unloading, or handling. Geotextile having defects or damage shall be examined by the Owner's Representative to determine its acceptability.

Wrappings protecting geotextile rolls shall be removed less than one hour prior to unrolling the geotextile. The geotextile shall not be exposed to sunlight for more than 15 days, unless otherwise specified or guaranteed by the Geotextile Manufacturer.

5.1.4 Conformance Sampling and Testing

Conformance sampling and testing of the geotextile shall be performed by the Owner's Representative in accordance with the minimum sampling frequencies outlined in Tables 5a and 5b of this CQA Plan. Conformance testing will be completed according to the following procedure:

- ▶ Cut a sample from the geotextile that is 3 feet long by the full roll width. Do not include the first 3 feet of the roll. Mark the samples with an arrow indicating the machine direction of the geotextile.
- ▶ Label the sample and include all pertinent project and geotextile product information.
- ▶ Complete chain-of-custody and testing request forms and forward conformance samples to the Geosynthetics CQA Laboratory.

The Owner's Representative shall review results from all conformance testing to verify compliance with requirements. If all requirements are met, the Owner's Representative shall issue written acceptance of the geotextile for deployment. If the requirements are not met, the Owner's Representative shall notify the Contractor and either resample/retest the failed roll/panel or mark the failed roll/panel as rejected. If the failed roll/panel is rejected, the Owner's Representative shall obtain conformance samples from the closest numerical roll/panel on each side of the failed roll/panel number. The two additional geotextile samples must conform to Table 5a (included in this CQA Plan) for the applicable geotextile. If either sample fails, the five numerically closest untested rolls on both sides of the failed sample will be tested by the Geosynthetics CQA Laboratory. These 10 samples must conform to the Specifications. If any of these samples fail, every roll of geotextile on-site and every subsequently delivered roll that is from the same supplier must be tested by the Geosynthetics CQA Laboratory for conformance.

5.1.5 Handling and Placement

All geotextile deployment and seaming operations shall be performed in the presence of the Owner's Representative and QC Team. During geotextile deployment, the Owner's Representative and the QC Team should verify and/or document the following:

- ▶ On slopes, the geotextile is to be securely anchored and rolled down the slope in such a manner as to continually keep the geotextile in tension.
- ▶ In the presence of wind, all geotextiles are ballasted with sandbags or equivalent. Sandbags shall be installed during placement and shall remain until replaced with soil cover.
- ▶ Geotextile is kept continually under slight tension to minimize the presence of wrinkles in the geotextile.
- ▶ Geotextiles are cut with an approved geotextile cutter only. Special care is taken to protect the underlying geomembrane from damage which could be caused by the cutting of geotextile.
- ▶ The Installer takes any necessary precautions to prevent damage to the underlying layers during placement of the geotextile.
- ▶ During placement of geotextiles, care is taken to prevent the entrapment of stones, excessive dust, or moisture that could damage the underlying geomembrane or hamper subsequent seaming.
- ▶ All cushion geotextiles are continuously heat bonded using a method acceptable to the Owner's Representative or sewn together with two rows of Type 401 stitching (field stitch).

- ▶ Cushion geotextiles are overlapped at a minimum of 6 inches prior to heat bonding or sewing.
- ▶ Sewing is done using thread made from the same type of polymer as the geotextiles being sewn together.

5.1.6 Repair

During geotextile installation, the Owner's Representative and QC Team shall visually inspect all panels and seams for holes or tears and shall mark any such areas for repair. The Owner's Representative shall verify that the repairs are made in accordance with acceptable geotextile repair methods identified in the Technical Specifications.

5.1.7 Final Inspection and Covering

The Owner's Representative shall complete a visual inspection of all geotextile panels, seams, and repairs prior to accepting the geotextile installation. The Owner's Professional Engineer shall personally conduct a final inspection on the completed facilities for the certification. The Installer shall place all material located on top of the geotextile in such a manner to ensure that there is no damage to the geotextile and geosynthetics, that there is minimal slippage of the geotextile on underlying layers, and that there is no excess tensile stresses in the geotextile.

5.2 Geomembrane

The geomembrane serves as the hydraulic barrier in the pond cap system. The pond geomembrane will be comprised of textured LLDPE and have a nominal thickness of 40 mil. All geomembrane installation activities will be monitored on a daily basis by the Owner's Representative and QC Team. The Owner's Professional Engineer shall personally conduct random inspections to check on his representative, the contractor, and other elements of construction.

5.2.1 Material

Prior to, or coincident with, shipment of geomembrane to the Project site, the Owner's Representative shall review and approve submittals from the Geomembrane Manufacturer, which shall include:

- ▶ Geomembrane Manufacturer's geomembrane specification sheet(s);
- ▶ Geomembrane MQC Certificates; and
- ▶ Other information required by the technical specifications.

No geomembrane shall be installed until the Owner's Representative has reviewed all certifications and supporting test data and determined that the geomembrane furnished for the Project is acceptable for use.

5.2.2 Pre-Installation Meeting

Prior to geomembrane installation, the Owner, Owner's Representative, Owner's Professional Engineer, and Geomembrane Installer shall attend a pre-installation meeting at the Project site. At this meeting, site safety and rules of operation, scheduling, methods of installation, and construction QC shall be discussed. The Geomembrane Installer and Owner's Representative shall at this time agree to the following:

- ▶ Acceptable weather conditions for geomembrane deployment and seaming;
- ▶ Geomembrane deployment, placement, and temporary anchorage methods;
- ▶ Trial seaming procedures and characteristics of acceptable welds;

- ▶ Non-destructive testing procedures;
- ▶ Destructive testing procedures and resolution of failed destructive tests; and
- ▶ Repair procedures.

Prior to installation, the geomembrane installer shall provide the Owner with a certification letter or form accepting the prepared subgrade. This letter will be included in the certification report for the geomembrane installation as discussed in this CQA Plan.

5.2.3 Delivery, Handling, and Storage

All geomembrane delivery, handling, and unloading shall be performed in the presence of the Owner's Representative. During unloading, the Contractor and Owner's Representative shall conduct an inspection of all delivered geomembrane for defects and damage caused by inadequate or improper packaging, shipping, unloading, or handling. Geomembrane identified as having defects or damage shall be examined by the Owner's Representative to determine its acceptability. If the Owner's Representative determines that only minor, repairable defects or damages are present, the geomembrane will be kept for use, pending acceptance of MQC testing and conformance testing. If the Owner's Representative determines that significant defects or damage are present, the geomembrane shall be marked as rejected and removed from the project site.

The Owner's Representative shall review packing slips or bills of lading to verify delivery of correct materials (i.e., geomembrane type, thickness, etc.). The Owner's Representative shall also verify that roll/panel numbers listed on packing slips match the roll/panel numbers on the geomembrane labels. If discrepancies are found, the Owner's Representative shall immediately notify the Contractor. Any geomembrane that has no label or where the label is damaged or otherwise illegible may either be sampled for laboratory analysis to determine its acceptability, or rejected and removed from the project site, as directed by the Owner's Representative. The Owner's Representative shall also verify that geomembrane production lots, and associated roll/panel numbers, delivered to the project site match the production lots and roll/panel numbers recorded on the approved MQC Certificates. If discrepancies are found, the Owner's Representative shall immediately notify the Contractor.

5.2.4 Conformance Sampling and Testing

Conformance sampling and testing of the geomembrane shall be performed by the Owner's Representative in accordance with the minimum sampling frequencies and test methods outlined in Tables 1 and 2 of this CQA Plan. Conformance sampling and testing shall be completed at a minimum frequency of one sample per geomembrane production lot according to the following procedure:

- ▶ Cut a sample from the geomembrane that is 3 feet long by the full roll/panel width wide.
- ▶ Mark the sample with arrows indicating the machine direction of the geomembrane.
- ▶ Label the sample and include all pertinent project and geomembrane product information.
- ▶ Complete chain-of-custody and testing request forms and forward conformance samples to a Geosynthetics CQA Laboratory for analysis.

The Owner's Representative shall review results from all conformance testing to verify compliance with the requirements of the Technical Specifications. If all requirements are met, the Owner's Representative shall issue written acceptance of the geomembrane for

deployment. If the requirements are not met, the Owner's Representative shall notify the Contractor and either resample/retest the failed roll/panel or mark the failed roll/panel as rejected. If the failed roll/panel is rejected, the Owner's Representative shall obtain conformance samples from the closest numerical roll/panel on each side of the failed roll/panel number. The two additional geomembrane samples must conform to the Technical Specifications. If either sample fails, the entire production lot will be marked as rejected and every roll/panel in the geomembrane production lots remaining on-site shall undergo conformance testing.

5.2.5 Deployment and Seaming

All geomembrane deployment and seaming operations shall be performed in the presence of the Owner's Representative and QC Team. Geomembrane shall only be deployed and seamed when weather conditions (temperature, humidity, precipitation, wind speed and direction, etc.) are within the limits established in the Technical Specifications and agreed to at the pre-installation meeting. The Owner's Representative shall document weather conditions during all geomembrane deployment and seaming operations.

All geomembrane field panels are to be labeled by the Geomembrane Installer using a unique panel "identification code" (number or letter-number combination) consistent with the labeling system agreed to during the pre-installation meeting. This identification code will be used for all CQA records. The Owner's Representative shall verify that the Manufacturer's roll/panel number and the date and time the panel are placed are marked on each of the field panels at the location(s) selected by the Owner's Representative. During geomembrane deployment, the Owner's Representative and QC Team shall verify and/or document the following:

- ▶ Geomembrane is only to be deployed on subgrade that has been installed in accordance with the Technical Specifications and the CQA Plan, and has been accepted by the Contractor, Geomembrane Installer, and Owner's Representative.
- ▶ Equipment and tools used to deploy and place geomembrane will not stretch, puncture, tear, or otherwise damage the geomembrane, and shall protect the underlying prepared subgrade from damage.
- ▶ Geomembrane is unrolled and placed in such a manner as to minimize dragging of panels into position ("spotting").
- ▶ Geomembrane is placed in the manner that minimizes or eliminates bridging ("trampolining") at the toe of slopes; orienting panel seams in a direction parallel to the line of maximum subgrade slope; shingling panels such that the "upstream" panel overlaps the "downstream" panel in order to minimize infiltration potential; and offsetting all panel seams parallel to the toe of a slope ("longitudinal seams") at the specified distance from the toe of the slope.
- ▶ Proper temporary anchorage and ballast is immediately used to prevent wind uplift, panel movement during field seaming, and bridging.
- ▶ The Geomembrane Installer's panel placement techniques and schedule minimize or eliminate the potential for accumulation of surface water runoff beneath the geomembrane. If any water is found ponded beneath the geomembrane after it has been installed, it shall be removed by the Contractor as directed by the Owner's Representative. Any compacted soil beneath installed geomembrane that has become excessively moist, soft, or unsuitable to perform its intended function, shall be removed and replaced by the Contractor as directed by the Owner's Representative.

All geomembrane panels shall be permanently seamed on the same day they are placed, except where explicitly approved by the Owner's Representative. Thermo-fusion seaming methods shall be used to join geomembrane panels in the field. For joining geomembrane panels, dual hot wedge is the preferred seaming method. For LLDPE geomembrane, extrusion welding shall be used for repairs, detailing, and other seams where thermo-fusion welding is not practical. Project seaming is a two-part process. The first part is referred to as trial seaming, where the equipment and technicians that are to perform the work are "qualified" to do so by having them prepare and evaluate test seams. The second part is referred to as production seaming, which entails the actual fabrication of field seams on deployed geomembrane panels. No production seaming shall commence until trial seaming is successfully completed and accepted by the Owner's Representative. During geomembrane seaming, the Owner's Representative and QC Team shall verify and/or document the following:

- ▶ Trial seams are prepared in the presence of the Owner's Representative or QC Team for each piece of seaming equipment in accordance with the frequencies and conditions required in the Technical Specifications. If any specimens fail to meet qualification criteria, the Owner's Representative may elect to have additional specimens from the sample tested in order to determine trial seam acceptance. If a trial seam fails to meet all qualification criteria, a new trial seam must be prepared and evaluated. If this second trial seam also fails, the seaming equipment and/or seaming technician preparing the trial seams shall not be allowed to perform production seaming until any deficiencies are corrected and two consecutive trial seams meeting all qualification criteria are prepared and accepted by the Owner's Representative.
- ▶ Geomembrane sheets that are to be production-seamed are positioned to create acceptable overlap and the overlap areas are free of dirt, dust, moisture, or other foreign material.
- ▶ All geomembrane production seams are labeled by the Geomembrane Installer with the date and time welding of the seam was started and completed, the seaming technician initials and seaming machine identification number, and all applicable seaming parameters (set temperature, rate of travel, etc.) used to prepare the seam.
- ▶ No folds, wrinkles, or "fish-mouths" are present within any seam areas. Where wrinkles or folds occur, the material shall be cut, overlapped, and a patch applied.
- ▶ The entire length (100 percent) of all production seams are non-destructively tested by the Geomembrane Installer to verify seam continuity. Non-destructive testing shall be performed in the presence of the Owner's Representative or QC Team.
- ▶ Production seam samples suitable for laboratory destructive testing are obtained by the Geomembrane Installer at locations established by the Owner's Representative as production seaming progresses. The Owner's Representative shall representatively sample all seaming equipment and welding technicians at the rates established. All samples are to be forwarded by the Owner's Representative to a Geosynthetics CQA Laboratory where they shall be destructively tested in peel and shear in accordance with ASTM D 6392.
- ▶ Review all laboratory testing data to verify that all production seam destructive testing meets the requirements of Table 3 of this CQA Plan. If any specimens fail to meet qualification criteria, the Owner's Representative may elect to have additional specimens from the sample tested in order to determine production

seam acceptance. If a destructive test sample fails to meet all qualification criteria, the Geomembrane Installer shall obtain two additional production seam samples, each a distance of approximately 10 feet in opposite directions from the original sample, for laboratory destructive testing. In order for the production seam to be accepted, the failed destructive test sample shall be bounded by two passing destructive test samples, and the seam between the two passing test locations shall be reconstructed. Alternatively, the entire length of the seam in question may be repaired by placement of a cap strip, or by another repair procedure, as directed by the Owner's Representative.

5.2.6 Repairs

During geomembrane installation, the Owner's Representative and QC Team shall visually inspect all geomembrane panels and seams for damage or defects, and shall mark any such areas for repair. The Owner's Representative shall verify that the Geomembrane Installer repairs marked areas as soon as possible and that any defects that could allow surface water runoff beneath the geomembrane are repaired on the same day they are marked. The Owner's Representative shall also verify that repairs are made in accordance with acceptable geomembrane repair methods and that all repairs are non-destructively tested.

5.2.7 Final Inspection/Covering

The Owner's Representative shall complete a final visual examination of all geomembrane panels, seams, and repairs prior to accepting the geomembrane installation. The Owner's Professional Engineer shall personally conduct a final inspection on the completed facilities for the certification. The Geomembrane Installer shall repair and test any areas identified during the Owner's Representative's final inspection as not being acceptable. No LLDPE geomembrane shall be covered with geotextile until it has been accepted by the Owner's Representative. Once accepted, LLDPE geomembrane shall be covered as soon as possible.

5.3 Geocomposite Drainage Net

Geocomposite used in the geosynthetic cap system is identified as GDN on the Drawings and in the Technical Specifications. The GDN has nonwoven geotextiles heat bonded to both sides of the high density polyethylene (HDPE) geonet.

The QC team will be responsible for completing or verifying the completion of the liner installation records completed by the Geosynthetics Installer. Forms CQA.1, CQA.3, CQA.6, and CQA.9 are provided as examples of typical installation documentation forms. These forms are for example only, alternate forms may be used to document the installation.

5.3.1 Manufacturing

The GDN Manufacturer shall provide the Owner's Representative with a list of certified properties for the type of GDN to be supplied. The GDN Manufacturer shall provide the Owner's Representative with written certification signed by a responsible party that the GDN delivered has properties, which meet or exceed the certified properties. In addition, at least two transmissivity tests on the GDN shall be performed by the QC team using the actual site materials and loading conditions. The transmissivity tests shall be performed in accordance with the procedures outlined on Table 8. The minimum transmissivity shall be as required by the Technical Specifications.

The QC team will examine all manufacturers' certifications and test results to ensure that the property values listed on the certifications meet or exceed those specified. Any deviations will be reported to the Owner's Representative.

5.3.2 Labeling

The GDN Manufacturer shall identify all rolls of GDN with the following:

- ▶ Manufacturer's name;
- ▶ Product designation;
- ▶ Lot number;
- ▶ Roll number;
- ▶ Roll dimensions and weight; and
- ▶ Geotextile orientation (leak detection GDN only).

The QC team will examine rolls upon delivery and any deviation from the above requirements will be reported to the Owner's Engineer.

5.3.3 Shipment and Storage

GDN cleanliness is essential to its performance and GDN rolls shall be wrapped in polyethylene sheets or otherwise protected against dust and dirt during shipping and storage.

The wrapping shall be removed less than one hour before placement. The QC team will verify that the GDN is free of dirt and dust just before installation. The QC team will report the outcome of this verification to the Owner's Representative, and if the GDN is judged dirty or dusty, it shall be washed by the Installer prior to installation.

Washing operations will be observed by the QC team and improper washing operations will be reported to the Owner's Representative.

5.3.4 Conformance Testing

Tests

Upon delivery of the rolls of GDN, the QC team will ensure that samples are removed and forwarded to the Geosynthetic CQA Laboratory for testing to ensure conformance to both the Specifications and manufacturer's certified properties. Conformance sampling and testing will be performed in accordance with Table 8 of this CQA Plan.

In addition to the conformance sampling shown on Table 8, the Owner's Representative shall conduct gradation testing on the soils to be used for the cover soils to verify the cover soils are stable (internally filtering) or compatible with the proposed GDN geotextile. If the cover soils are not internally filtering, they should be tested for compatibility with the GDN using hydraulic conductivity ratio testing or other testing approved by the owner's representative.

Sampling Procedures

Samples will be taken across the entire width of the roll and will not include the first 3 feet. Unless otherwise specified, samples will be 3 feet long by the roll width. The QC team will mark the machine direction on the samples with an arrow.

Test Results

The QC team will examine all results from laboratory conformance testing and will report any nonconformance to the Owner's Representative. The minimum standards for GDN are provided in Table 8 of this CQA Plan and in the Technical Specifications.

Conformance Test Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the Geosynthetics CQA Laboratory:

- ▶ The Installer shall replace the roll of GDN that is in non-conformance with the Technical Specifications with a roll that meets the Technical Specifications; and
- ▶ The Installer shall remove conformance samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must conform to the Technical Specifications. If either of these samples fail, the five numerically closest untested rolls on both sides of the failed sample will be tested by the Geosynthetics CQA Laboratory. These 10 samples must conform to the Technical Specifications. If any of these samples fail, every roll of GDN on-site and every subsequently delivered roll that is from the same supplier must be tested by the Geosynthetics CQA Laboratory for conformance to the Technical Specifications. This additional conformance testing will be at the expense of the Installer.

The QC team will document actions taken in conjunction with conformance test failures.

5.3.5 Handling and Placement

Field Panel Placement

Form CQA.6 shall be completed daily.

Location

The QC team will verify that field panels are installed at the location indicated on the Installer's field installation drawings, as approved or modified.

Placement

The Installer shall handle all GDN in such a manner as to ensure that it is not damaged in any way, and the following shall be complied with:

- On slopes, the GDN shall be secured in the cap perimeter termination area and then rolled down the slope in such a manner as to continually keep the GDN in continuous contact with the geomembrane surface. If necessary, GDN shall be positioned by hand after being unrolled to minimize wrinkles.
- In the presence of wind, GDN shall be ballasted with sandbags or equivalent. Such sandbags shall be installed during placement and shall remain until replaced with overlying material.
- Unless otherwise specified, GDN shall not be welded to geomembranes. No burn-through geotextiles shall be permitted. No glue or adhesive shall be permitted.
- The Installer shall take any necessary precautions to prevent damage to the underlying layers during placement of the GDN.
- During placement of GDN, care shall be taken not to entrap dirt or excessive dust that could cause clogging of the system and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the GDN, it shall be hosed clean prior to placement of the next material on top of it. In this regard, care shall be taken with the handling of sandbags to prevent rupture or damage of the sandbag.
- In no instance shall equipment travel directly on the geomembrane. Only track equipment with ground pressures less than or equal to 5 pounds per square inch shall be allowed to routinely cross geomembrane or geotextile areas provided a minimum of 12 inches of cover is maintained. Rubber-tired vehicles

can occasionally cross the area as long as 18 inches of cover is maintained and the vehicle wheels do not slip. For all temporary access roads crossing a geosynthetic cap system edge, or for access roads over the geosynthetic cap system in order to end dump protective cover or waste, the contractor shall maintain a 3-foot (minimum) layer of approved cover material over the geosynthetic cap system.

The QC team will note any non-compliance and report it to the Owner's Representative.

5.3.6 Joining

Adjacent GDN panels shall be joined according to the Technical Specifications. As a minimum, the following requirements shall be met:

- ▶ A combination of lap joints (geonet) and sewing (geotextile) shall be used to join GDN panels in the field. A minimum geonet overlap of 3 inches shall be used for panel edges and a minimum GDN overlap of 24 inches shall be used for panel ends. At the panel butt ends, geotextile of the same weight as the top geotextile on the GDN shall be placed over the GDN overlap and heat bonded to the adjoining GDN panels, with a minimum overlap of 12 inches on either side.
- ▶ Thermal seaming methods may be accepted if successfully demonstrated in the field and approved by the Owner's Representative and CQA Consultant.
- ▶ Tying shall be achieved by nylon cable or HDPE fasteners. Tying devices shall be white or yellow to aid the QC team with visual inspection. Metallic devices shall not be used.
- ▶ Tying fasteners shall be spaced every 5 feet along panel edges, every 6 inches across panel ends and in corners, and every 6 inches in the perimeter geosynthetic cap system termination area. This requirement may be omitted at butt ends on flat slopes if approved by the Owner's Engineer and Manufacturer; and
- ▶ The QC team will note any non-compliance and report it to the Owner's Representative.

5.3.7 Repair

Any holes or tears in the GDN shall be repaired by placing a patch extending 12 inches beyond edges of the hole or tear. The patch shall be secured to the original GDN by tying fasteners every 6 inches. If the hole or tear width across the roll is more than 50 percent the width of the roll, the damaged area shall be cut out and the two portions of the GDN will be joined.

The QC team will observe any repair, note any non-compliance with the above requirements, and report them to the Owner's Representative.

6.0 Final Cover System Drainage

The cover system drainage components include nonwoven filter geotextile, subsurface drainage pipe and underdrain pipes as described below.

6.1 Nonwoven Filter Geotextile

Nonwoven Filter geotextile shall consist of an 8 oz./sq.yd., non-woven polypropylene geotextile, and shall conform the requirements of Table 6.

6.1.1 Conformance Sampling and Testing

Conformance sampling and testing of the geotextile shall be performed by the Owner's Representative in accordance with the minimum sampling frequencies outlined in Table 6 of this CQA Plan. Conformance testing will be completed according to the following procedure:

- ▶ Cut a sample from the geotextile that is 3 feet long by the full roll width. Do not include the first 3 feet of the roll. Mark the samples with an arrow indicating the machine direction of the geotextile.
- ▶ Label the sample and include all pertinent project and geotextile product information.
- ▶ Complete chain-of-custody and testing request forms and forward conformance samples to the Geosynthetics CQA Laboratory.

The Owner's Representative shall review results from all conformance testing to verify compliance with requirements. If all requirements are met, the Owner's Representative shall issue written acceptance of the geotextile for deployment. If the requirements are not met, the Owner's Representative shall notify the Contractor and either resample/retest the failed roll/panel or mark the failed roll/panel as rejected. If the failed roll/panel is rejected, the Owner's Representative shall obtain conformance samples from the closest numerical roll/panel on each side of the failed roll/panel number. The two additional geotextile samples must conform to Table 6 (included in this CQA Plan) for the applicable geotextile. If either sample fails, the five numerically closest untested rolls on both sides of the failed sample will be tested by the Geosynthetics CQA Laboratory. These 10 samples must conform to the Specifications. If any of these samples fail, every roll of geotextile on-site and every subsequently delivered roll that is from the same supplier must be tested by the Geosynthetics CQA Laboratory for conformance.

6.1.2 Final Inspection and Covering

The Owner's Representative shall complete a visual inspection of all geotextile panels, seams, and repairs prior to accepting the geotextile installation. The Owner's Professional Engineer shall personally conduct a final inspection on the completed facilities for the certification. The Installer shall place all material located on top of the geotextile in such a manner to ensure that there is no damage to the geotextile and geosynthetics, that there is minimal slippage of the geotextile on underlying layers, and that there is no excess tensile stresses in the geotextile.

6.2 Subsurface Drain and Underdrain Pipe

The subsurface drain piping system will consist of a network of 6 inch, 8 inch, and 12 inch diameter solid wall and perforated wall HDPE pipe, which is bedded in a coarse aggregate drainage layer and wrapped on nonwoven filter geotextile located within the soil cover. The piping system is utilized to drain soil cover infiltration water to assist in minimizing head build up on the geomembrane.

The underdrain drain piping system will consist of a network of 6-inch diameter perforated wall pipe, which is bedded in a coarse aggregate drainage layer and wrapped in underdrain geotextile, and will be located within the pond ash beneath the geosynthetic cap system. The underdrain is utilized to drain pond ash upon soil cover loading and to prevent hydrostatic uplift on the geosynthetic cap system.

Product information for the HDPE subsurface drain pipe and underdrain pipe is specified in the Technical Specifications. The Owner's Representative shall approve the HDPE pipe product information to be installed. The installation of the underdrain piping and coarse aggregate will be monitored daily by the QC Team product to verify compliance with the Drawings and Technical Specifications.

6.3 Aggregate

The material shall be clean, sound, tough, durable, angular, subangular, and free from slag, cinders, ashes, rubbish, or other deleterious material, in accordance with the VA Department of Transportation Section 203. In addition, soluble calcium carbonate of underdrain aggregate shall not exceed 10 percent by weight. Aggregate shall be placed in maximum 6-inch loose lifts. Gravel placed as pipe bedding shall be compacted, no compaction shall occur on the sides of the drain piping, and compaction shall not occur above the pipe until a minimum of 12 inches of gravel is placed above the pipe. Aggregate shall be compacted with a minimum of four passes of a plate compactor.

7.0 Final Cover System Soil Cover

The purpose of the soil cover layer is to provide freeze/thaw protection to the geosynthetics cap system, and to provide a base for establishment of vegetative cover, which aids in prohibiting damage to the geosynthetic cap system and limits surface water infiltration to minimize potential instability of the system. All ongoing activities will be monitored daily by the Owner's Representative and the QC Team.

7.1 Material

The material used to construct the Protective Cover soil and vegetative support soil layer shall be free of construction debris, cobbles and boulders, or other deleterious material.

7.2 Placement

Final cover lift placement and compaction control shall conform to all of the following requirements:

- If screening is not performed on Protective Cover Soil, the Contractor shall have a minimum of three people to remove oversized material from the Protective Cover Soil and help flatten wrinkles and prevent damage to geomembrane during placement of the first lift. If screening is performed on Protective Cover Soil, the Contractor shall have a minimum of one person to help flatten wrinkles and prevent damage to geomembrane during placement of the first lift.
- The 18-inch Protective Cover Soil Layer shall be placed in two lifts.
- The 6-inch thick Vegetative Support Layer shall be placed in one lift.

7.3 Vegetation

QC inspection activities include observation to ensure that:

- Materials provided (e.g., soil, fertilizer, seed) meet specification requirements and are acceptable based on local regulations.
- During the construction care period (a minimum of a full growing season up to an one-year warranty provision) erosion protection is maintained.
- If required, periodic irrigation is utilized to produce satisfactory growth.

Areas that fail to show a uniform stand of grass shall be reseeded, fertilized, and mulched as necessary to establish satisfactory growth.

7.4 Final Inspection

Upon completion of the final cover system, the area shall be inspected to ensure a 90 percent vegetative growth. If insufficient growth is found the area shall be reseeded, fertilized, and mulched. The Owner's Professional Engineer shall personally conduct a final inspection on the completed facilities.

8.0 Miscellaneous Construction

8.1 Common Fill

The purpose of common fill is to provide soil for general site grading and backfill. All ongoing activities will be monitored daily by the Owner's Representative and the QC Team. Common fill will not contain unsuitable material, as defined in the Technical Specifications, or CCRs, as defined in Section 4.0. Common fill placement and monitoring requirements are provided in Tables 12 and 13.

8.2 Structural Fill

The purpose of the structural fill layer is to provide backfill materials for anchor trenches, as indicated, and concrete structures, for embankment construction of basins or ponds, foundation material for cellular concrete mattresses, or as designated on the drawings. All ongoing activities will be monitored daily by the Owner's Representative and the QC Team. Structural fill will not contain unsuitable material or contaminated material, as defined in Section 3.0, or CCRs, as defined in Section 4.0. Structural fill placement and monitoring requirements are provided in Tables 2 and 13.

8.3 Separation Geotextile

Separation geotextile shall consist of a 12 oz./sq.yd. non-woven polypropylene geotextile, and shall conform to the requirement of Table 7.

8.3.1 Conformance Sampling and Testing

Conformance sampling and testing of the geotextile shall be performed by the Owner's Representative in accordance with the minimum sampling frequencies outlined in Table 7 of this CQA Plan. Conformance testing will be completed according to the following procedure:

- ▶ Cut a sample from the geotextile that is 3 feet long by the full roll width. Do not include the first 3 feet of the roll. Mark the samples with an arrow indicating the machine direction of the geotextile.
- ▶ Label the sample and include all pertinent project and geotextile product information.
- ▶ Complete chain-of-custody and testing request forms and forward conformance samples to the Geosynthetics CQA Laboratory.

The Owner's Representative shall review results from all conformance testing to verify compliance with requirements. If all requirements are met, the Owner's Representative shall issue written acceptance of the geotextile for deployment. If the requirements are not met, the Owner's Representative shall notify the Contractor and either resample/retest the failed roll/panel or mark the failed roll/panel as rejected. If the failed roll/panel is rejected, the Owner's Representative shall obtain conformance samples from the closest numerical roll/panel on each side of the failed roll/panel number. The two additional geotextile samples must conform to Table 7 (included in this CQA Plan) for the applicable geotextile. If either sample fails, the five numerically closest untested rolls on both sides of the failed sample will be tested by the Geosynthetics CQA Laboratory. These 10 samples must conform to the specifications. If any of these samples fail, every roll of geotextile on-site and every subsequently delivered roll

that is from the same supplier must be tested by the Geosynthetics CQA Laboratory for conformance.

8.3.2 Final Inspection and Covering

The Owner's Representative shall complete a visual inspection of all geotextile panels, seams, and repairs prior to accepting the geotextile installation. The Installer shall place all material located on top of the geotextile in such a manner to ensure that there is no damage to the geotextile and geosynthetics, that there is minimal slippage of the geotextile on underlying layers, and that there is no excess tensile stresses in the geotextile.

9.0 Documentation and Certification

9.1 Introduction

An effective CQA Plan depends largely on recognition of all construction activities that should be monitored, and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of QC activities. The Owner's Representative shall document that QC requirements have been addressed and satisfied. The Owner's Representative or QC Team shall be responsible for completing daily logs and data sheets to verify that all monitoring activities have been carried out. The Owner's Representative or QC Team shall also maintain, at the job site, a complete file of design plans, design specifications, the CQA Plan, checklists, test procedures, daily logs, and other pertinent documents. Sample CQA forms, which the QC Team or Geosynthetics Installer will be required to complete, are included in this CQA Plan. Similar forms may be used in lieu of these sample CQA forms.

9.2 Certification of Major Construction Activities

The Owner's Engineer shall prepare a certification report at the completion of construction. The major construction activities to be documented in the certification report include the following:

- Low Permeability Soil Liner;
- Prepared Subgrade Surface;
- GCL Installation;
- Cushion Geotextile Installation;
- Geomembrane Installation;
- GDN Installation;
- Drain Pipe/Trench Installation; and
- Soil Cover.

The certification shall describe activities associated with the construction of the item, including construction procedures, observations, and tests performed by the QC Team. At a minimum, the certification report shall include:

- Summaries of construction activities;
- Observation logs and test data sheets including sample location plans, and supporting field and laboratory test results;
- Construction problems and solutions reports;
- Changes from design and material specifications;
- As-built drawings; and

- The certification report shall be signed and sealed by the Owner's Engineer (PE registered in VA).

The as-built drawings shall include scale plans depicting the location of the construction, and details pertaining to the extent of the construction (e.g., depths, plan dimensions, elevation, soil component thicknesses, etc.). Surveying and base maps required for development of the as-built drawings shall be prepared by the Contractor's Professional Licensed Surveyor. The drawings shall specifically identify any significant deviations from the permit drawings and shall be prepared in the coordinate system used by the construction drawings.

9.3 Storage of Records

Data sheets, reports, and other relevant documentation shall be compiled in a single document and stored on-site. Other reports may be stored by any standard method that allows for easy access.

10.0 Surveying

Surveying of lines and grades shall be conducted on an ongoing basis during construction of the soil layers, pipe, and geosynthetics placement. Surveying is to provide documentation for record drawings and verify construction. The Owner's Engineer, or his representative, will perform periodic inspections, and will review and approve as-built plans. The Owner's Representative will only spot check the work as he deems necessary. The surveying conducted at the site shall be the responsibility of the contractor. The surveyor and contractor shall remove all stakes from the geosynthetic cap area immediately after they are broken or no longer required for grade control. They must assure that no stakes will be in the fill below or above the liner.

10.1 Survey Control

Permanent benchmarks will be established for the site at a location convenient for daily tie-in. The vertical and horizontal controls for these benchmarks will be established within normal land surveying standards.

10.2 Surveying Personnel

All surveying shall be performed under the direct supervision of a Professional Licensed Surveyor. All survey results shall be certified by a VA registered professional land surveyor.

10.3 Precision and Accuracy

A wide variety of survey equipment is available to meet the requirements of this project. The survey instruments used for this work shall be sufficiently precise and accurate to attain third order survey for traverse and leveling surveys. All survey instruments should be capable of distance measurements to a precision of 0.01-foot and with angle readings of 20 sec.

10.4 Conformance Survey Requirements

Tolerances, Lines, Grades and the necessary conformance surveys and record drawings are specified in the Construction Specifications.

10.5 Documentation

All field survey notes will be retained by the Owner's Representative. A copy of these reduced notes shall be given to the Owner at the end of the surveying task. The results from the field surveys shall be documented on a set of Survey Record Drawings compatible in AutoCad, Format Release 2010 or newer, including point blocks and contours, where applicable. These drawings should at least include all of the information required in this document. The drawings will be updated by the Owner's Engineer if required.

SAMPLE CQA FORMS

GEOSYNTHETICS RECEIVING / FIELD INVENTORY RECORD

PROJECT: Impoundment Closure Project – Possum Point Power StationPROJECT NO.: C150132.00

INVENTORY DATE/TIME: _____ CQA TECHNICIAN: _____

WEATHER CONDITIONS: _____

STORAGE AREA LOCATION & CONDITIONS: _____

CARRIER: _____ SHIPMENT NO.: _____

DRIVER: _____ DELIVERY DATE/TIME: _____

UNLOADED BY: _____ EQUIPMENT: _____

COMMENTS: _____

MANUFACTURER: _____ PRODUCT: _____

	BATCH / LOT NUMBER	ROLL NUMBER	DIMENSIONS		CONFORMANCE SAMPLE NUMBER	DAMAGE / COMMENTS
			WIDTH (ft)	LENGTH (ft)		
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

SUBBASE ACCEPTANCE RECORD

PROJECT: Impoundment Closure Project – Possum Point Power Station PROJECT NO.: C150132.00

LOCATION: Possum Point Power Station, Prince William County VA

EARTHWORK CONTRACTOR

NAME: _____ ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

PROJECT SUPERINTENDENT: _____ PHONE: _____

GEOSYNTHETICS INSTALLER

NAME: _____ ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

PROJECT SUPERINTENDENT: _____ PHONE: _____

SUBBASE ACCEPTANCE CERTIFICATION

DATE: _____ TIME: _____ REF. SKETCH: _____

This form documents that the Subbase delineated on the attached sketch is acceptable for installation of GCL and secondary HDPE geomembrane. The Subbase has been prepared in accordance with the Contract Drawings and Specifications and has been inspected and approved by the parties below at the date and time listed above. Any changes in Subbase conditions due to weather, vehicular traffic, or other causes will require re-approval of the affected areas after necessary repairs are completed. This document only applies to the Subbase surface and does not constitute acceptance of the GCL and secondary HDPE geomembrane installation.

EARTHWORK CONTRACTOR SIGNATURE: _____ DATE: _____

PRINT NAME: _____

PRINT TITLE: _____

GEOSYNTHETICS INSTALLER SIGNATURE: _____ DATE: _____

PRINT NAME: _____

PRINT TITLE: _____

CQA CONSULTANT SIGNATURE: _____ DATE: _____

PRINT NAME: _____

PRINT TITLE: _____

CQA.5

GEOMEMBRANE TRIAL SEAM RECORD

PROJECT: Impoundment Closure ProjectPROJECT NO.: C150132.00 DATE: _____LOCATION: Possum Point Power Station, Prince William County, VA

CQA TECHNICIAN: _____

CONTRACTOR: _____

INSTALLER: _____

FUSION WELDS								PROJECT CRITERIA (lbs): <u>90</u> (PEEL) <u>112</u> (SHEAR)								
TIME	AMB. TEMP.	SEAMING TECH.	MACHINE NO.	WEDGE TEMP.		TRAVEL SPEED		PEEL (lbs)					SHEAR (lbs)		P / F	COMMENTS
				SET	ACTUAL	SET	ACTUAL	1	2	3	4	5	1	2		

EXTRUSION WELDS								PROJECT CRITERIA (lbs): <u>81</u> (PEEL) <u>112</u> (SHEAR)								
TIME	AMB. TEMP.	SEAMING TECH.	MACHINE NO.	BARREL TEMP.		PREHEAT TEMP.		PEEL (lbs)					SHEAR (lbs)		P / F	COMMENTS
				SET	ACTUAL	SET	ACTUAL	1	2	3	4	5	1	2		

CQA.6

GEOSYNTHETICS DAILY PLACEMENT RECORD

PROJECT: Impoundment Closure Project

LOCATION: Possum Point Power Station,
Prince William County VA

PROJECT NO.: C150132.00









MATERIAL: _____

CQA TECHNICIAN: _____

DATE	TIME	PANEL NUMBER	ROLL NUMBER	PANEL LENGTH (ft)	PANEL WIDTH (ft)	PANEL AREA (ft²)	COMMENTS

GEOMEMBRANE PANEL INSPECTION RECORD

SYMBOLS / SYMBOL DEFINITIONS

ZONE 1		AIR PRESSURE ZONE
		REPAIR NEEDED
		REPAIR COMPLETED
		REPAIR TESTED
		REPAIR APPROVED
		DESTRUCTIVE SAMPLE REPAIR
		CAP STRIP REPAIR
		EXTRUSION WELD

DEFECT CODES / DEFECT CODE DEFINITIONS

BT	BURN THROUGH
CR	CREASE
DS-1	DESTRUCTIVE SAMPLE & NO.
ED	CONST. EQUIPMENT DAMAGE
FM	FISH MOUTH
PTC	PRESSURE TEST CUT
SI	SOIL SURFACE IRREGULARITY
T	JOINT (SEAM INTERSECTION)
VL	VACUUM TEST LEAK
WK	WRINKLE
WR	WELDER RESTART

GENERAL CODES / GENERAL CODE DEFINITIONS

AT	ANCHOR TRENCH
EOS	END OF SEAM
VBT	VACUUM BOX TESTED
DTF	DUAL TRACK FUSION
SWW	SINGLE WEDGE WELD
EXT	EXTRUSION WELD

GEOMEMBRANE SEAM INSPECTION RECORD

PROJECT: Impoundment Closure Project - Possum Point Power StationPROJECT NO.: C150132.00

CONTRACTOR: _____

INSTALLER: _____

COMMENTS: _____

☐ FINAL INSPECTION/ACCEPTED

SEAM NO.: _____

DATE WELDED: _____

TIME WELDED: _____ A.M./P.M.

SEAMING TECH.: _____

MACHINE NO.: _____

WELDING MACHINE TYPE: _____

SEAM LENGTH: _____

SEAM DETAIL (Show Panels & Dimensions)

1. Air Pressure Testing

Zone	Length (ft)	Start Time	Start Pressure (psi)	End Time	End Pressure (psi)	Pressure Loss (psi)	Approved (Y/N)	Approved By

2. Vacuum Box Testing

Zone	Length (ft)	Date Tested	Approved (Y/N)	Date Repaired	Date Retested	Approved By

3. Seam Repairs (Patches and Cap Strips)

REPAIR NO.	DEFECT TYPE	REPAIR DATE	NDT TYPE & DATE	APPROVED BY

GEOSYNTHETICS DAILY SUMMARY REPORT

PROJECT: Impoundment Closure Project – Possum Point Power Station

DATE: _____

PROJECT NO.: C150132.00

AMBIENT TEMPERATURE RANGE: _____

CONTRACTOR: _____

WEATHER CONDITIONS: _____

INSTALLER: _____

INSTALLED TODAY (SF)

TOTAL TO DATE (SF)

Underdrain Geotextile

GCL

Cushion Geotextile

Textured 40-mil LLDPE

GDN

Nonwoven Fitter Geotextile

Separation Geotextile

CCM Geotextile

Microgrid

WELDING TECH	SEAM LENGTHS (LF)	TOTAL LF SEAMED	D.S. NO.	D.S. SEAM NO.	DATE TO LAB	RESULT	RESULT DATE

LF SEAMED TODAY: S _____ P _____ LF SEAMED TO DATE: S _____ P _____

D.S. SAMPLING RATE = LF SEAMED TO DATE / D.S. SAMPLES TO DATE: S _____ P _____

DETAILED TODAY S _____% P _____% TOTAL TO DATE: S _____% P _____%

AIR TESTED TODAY (PASSING) S _____% P _____% TOTAL TO DATE: S _____% P _____%

V-BOXED TODAY (PASSING) S _____% P _____% TOTAL TO DATE: S _____% P _____%

COMMENTS: _____

CQA REPRESENTATIVE SIGNATURE

TABLES

Table 1.
CQA Conformance Sampling and Testing Requirements for Geomembrane.

Test ^{(1),(2)}	Frequency and Timing	Acceptance Parameters	Test Failure Procedures
Core Thickness (ASTM D5994)	At least one per 500,000 square feet (ft ²) prior to installation	38 mil (min ave) ⁽³⁾	Reject/replace non-conforming material and test replacement material
Tensile Properties (ASTM D6693, Type IV)-Break Strength Break Elongation	At least one per 500,000 ft ² prior to installation	103 ppi (min ave) 400 percent (min ave)	Reject/replace non-conforming material and test replacement material
Tear Strength (ASTM D1004)	At least one per 500,000 ft ² prior to installation	22 pounds (lbs) (min ave)	Reject/replace non-conforming material and test replacement material
Puncture Resistance (ASTM D4833)	At least one per 500,000 ft ² prior to installation	48 lbs (min ave)	Reject/replace non-conforming material and test replacement material
Interface Shear Strength (ASTM D5321)	At least one per 500,000 ft ² (two minimum) prior to installation	See Table 2 of this CQA Plan	Reject/replace non-conforming material and test replacement material
Asperity Height (ASTM 7466)	At least one per 500,000 ft ² prior to installation	16 mil (min ave) ⁽⁴⁾	Reject/replace non-conforming material and test replacement material
Density (ASTM D1505/D792)	At least one per 500,000 ft ² prior to installation	0.939 g/cc (max ave)	Reject/replace non-conforming material and test replacement material
Carbon Black Content (ASTM D1603)	At least one per 500,000 ft ² prior to installation	2.0 to 3.0 percent	Reject/replace non-conforming material and test replacement material

Notes:

- ¹ The required properties specified herein may be revised by the Engineer to reflect new or revised test methods or to conform with improvements to the state-of-the-practice.
- ² Number of specimens per test established in applicable test method unless otherwise noted.
- ³ Lowest individual value for eight out of 10 readings = 54 mil; lowest individual value for one out of 10 readings = 31 mil.
- ⁴ Alternate side of sheet measured each time a roll is tested.

Table 2.
Interface Shear Strength Requirements for Textured 40 Mil LLDPE Geomembrane. ^(1, 2, 3)

Testing Set-Up		
ASTM D5321	Conditioning:	Set up each test to match field placement orientation. Run all tests under wet conditions.
	Procedure A:	Geomembrane against Cushion Geotextile Substrate: Project Cushion Geotextile Superstratum: Project Textured 40 Mil LLDPE Geomembrane Displacement Rate: 0.04-inch per minute (ipm) (maximum) Total Displacement: 2.50-inch (minimum)
	Procedure B:	Geomembrane against GDN Substrate: Project textured 40 Mil LLDPE Geomembrane Superstratum: Project GDN Displacement Rate: 0.04 ipm (maximum) Total Displacement: 2.50 inches (minimum)
	Procedure C:	Geomembrane against Prepared Subgrade Substrate: Project Textured 40 Mil LLDPE Geomembrane Superstratum: Project Prepared Subgrade Displacement Rate: 0.04 ipm (maximum) Total Displacement: 2.50 in (minimum)
	Special Instructions:	None.
Strength Requirements		
Normal Stress [Pounds per Square Foot (psf)]		Minimum Peak Shear Strength
150		20 degrees
300		
600		
1000		

Notes:

- ¹ Test individual interfaces between Steel rasp platens. In lieu of testing individual interfaces, a system test may be performed using a configuration that allows failure to occur through the weakest shearing plane. System test configuration, conditions, and procedures must be accepted by the Engineer prior to submitting test results for review and approval.
- ² Interfaces shall be saturated for a minimum of 24 hours prior to testing.
- ³ Geosynthetics shall be oriented such that the shear force is parallel to the down slope orientation of these components in the field.

Table 3.
Seam Qualification Criteria for Textured 40 Mil-LLDPE Geomembrane. ⁽¹⁾

	Trial Seaming^(2, 4,6)	Production Seaming^(3, 5, 6, 7)
Hot Wedge Seams		
Peel Strength (lbs)	50	50
Peel Incursion (%)	25	25
Shear Strength (lbs)	60	60
Shear Elongation at Break (%)	-	50
Extrusion Fillet Seams		
Peel Strength (lbs)	44	44
Peel Incursion (%)	25	25
Shear Strength (lbs/in)	60	60
Shear Elongation at Break (%)	-	50

Notes:

- ¹ Peel strengths, shear strengths, and shear elongations listed are minimum required values. Peel incursion percentages listed are maximum allowable values.
- ² Trial seams shall be prepared for each piece of seaming equipment whenever any of the following conditions occur:
 - Shift start-up;
 - Every four to six hours of continuous seaming within a shift;
 - "Cold" restart of seaming equipment;
 - Change in welding technician;
 - Significant change in geomembrane sheet temperatures; and
 - As required by the Owner's Representative.
- ³ Laboratory test in accordance with ASTM D6392.
- ⁴ For trial seaming, in order to be considered qualified, five trial seam test specimens must meet all strength and incursion requirements.
- ⁵ For production seaming, values listed for shear and peel are for four out of five test specimens; the fifth specimen can be as low as 80 percent of the listed value.
- ⁶ Seam tests for peel and shear must fail in the Film Tear Bond-mode. This is a failure in the ductile mode of one of the bonded sheets by tearing or breaking prior to complete separation of the bonded area.
- ⁷ Where applicable, both tracks of a double hot wedge seam shall be tested for peel adhesion.

Table 4.
CQA Conformance Sampling and Testing Requirements for Geocomposite Clay Liner. ⁽¹⁾

Material Property	Test Method	Test Frequency [ft ² (m ²)] ⁽²⁾	Required Values
Bentonite Swell Index ⁽³⁾	ASTM D 5890	At least one per 500,000 ft ² prior to installation	24 ml/2g min.
Bentonite Fluid Loss ⁽³⁾	ASTM D 5891	At least one per 500,000 ft ² prior to installation	18 ml max.
Bentonite Mass/Area ⁽³⁾	ASTM D 5993	At least one per 500,000 ft ² prior to installation	0.75 lb./ft ² (3.6 kg/m ²) min.
GCL Tensile Strength ⁽⁴⁾	ASTM D 6768	At least one per 500,000 ft ² prior to installation	50 lbs/in (53 N/cm) MARV
GCL Peel Strength ⁽⁴⁾	ASTM D 6496	At least one per 500,000 ft ² prior to installation	3.5 lbs/in (6.1 N/cm) min.
GCL Hydraulic Conductivity ⁽⁵⁾	ASTM D 5887	At least one per 500,000 ft ² prior to installation	5 x 10 ⁻⁹ cm/sec max.
GCL Hydrated Internal Shear Strength ⁶	ASTM D 5321 ASTM D 6243	At least one per 500,000 ft ² prior to installation	500 psf. (24 kPa) typ @ 200 psf

Notes:

- ¹ The required properties specified herein are satisfied by the Bentomat DN as manufactured by CETCO Lining Technologies but may be revised by the Engineer to reflect new or revised test methods or to conform with improvements in state-of-the practice.
- ² Number of specimens per test established in applicable test method unless otherwise noted.
- ³ Perform tests on as-received material before incorporation into finished GCL.
- ⁴ All tensile strength testing is performed in the machine direction using ASTM D6768. All peel strength testing is performed using ASTM D6496.
- ⁵ Permeability testing with de-aired distilled/deionized water at 80 psi (551kPa) cell pressure, 77 psi (531kPa) headwater pressure and 75 psi (517kPa) tailwater pressure.
- ⁶ Peak value measures at 200 psf normal stress for a specimen hydrated for 48 hours.

Table 5a.
CQA Conformance Sampling and Testing Requirements for Cushion Geotextiles.

Test ^{(1), (2)}	Frequency and Timing	Acceptance Parameters	Sample Location ⁽³⁾	Test Failure Procedures
Weight (ASTM D5261)	At least one per 500,000 ft ² prior to installation	12 oz./sq. yd. minimum	On-site material stockpile	Reject/replace non-conforming material and test replacement material
Grab Tensile Strength (ASTM D4632)	At least one per 500,000 ft ² prior to installation	300 lbs.	On-site material stockpile	Reject/replace non-conforming material and test replacement material
Grab Elongation (ASTM D4632)	At least one per 500,000 ft ² prior to installation	50 percent	On-site material stockpile	Reject/replace non-conforming material and test replacement material
Trapezoidal Tear Strength (ASTM D4533 in machine and cross-machine directions)	At least one per 500,000 ft ² prior to installation	115 lbs.	On-site material stockpile	Reject/replace non-conforming material and test replacement material
Puncture Strength (ASTM D6241)	At least one per 500,000 ft ² prior to installation	800 lbs.	On-site material stockpile	Reject/replace non-conforming material and test replacement material
Minimum Interface Shear Strength (ASTM D5321)	At least one per 500,000 ft ² (two minimum) prior to installation	See Table 5b of this CQA Plan	On-site material stockpile	Reject/replace non-conforming material and test replacement material

Notes:

- ¹ The required properties specified herein may be revised by the Engineer to reflect new or revised test methods or to conform with improvements to the state-of-the practice.
- ² Number of specimens per test established in applicable test method unless otherwise noted
- ³ The CQA Team may elect to have the Project material sampled at the manufacturer's factory and shipped to an independent testing laboratory for conformance testing.

Table 5b.
Interface Shear Strength Requirements for Cushion Geotextile. ⁽¹⁾

Testing Set-Up		
ASTM D5321	Conditioning:	Set up each test to match field placement orientation. Run all tests under wet conditions.
	Procedure A:	Cushion Geotextile against Prepared Subgrade Substrate: Prepared Subgrade Soil Compacted Simulating Field Conditions Superstratum: Project Cushion Geotextile Displacement Rate: 0.04 ipm (maximum) Total Displacement: 2.50 inches (minimum)
	Special Instructions:	None.
Strength Requirements		
Normal Stress [Pounds per Square Foot (psf)]		Minimum Peak Shear Strength
150		20 degrees
300		
600		
1000		

Note:

- ¹ Test individual interfaces between Steel rasp platens. In lieu of testing individual interfaces, a system test may be performed using a configuration that allows failure to occur through the weakest shearing plane. System test configuration, conditions, and procedures must be accepted by the Engineer prior to submitting test results for review and approval.

Table 6.
CQA Conformance Sampling and Testing Requirements for Nonwoven Filter Geotextile.

Test^{(1), (2)}	Frequency and Timing	Acceptance Parameters	Sample Location⁽³⁾	Test Failure Procedures
Weight (ASTM D5261)	One per 40 rolls prior to installation	8 oz./sq. yd. minimum	On-site material stockpile	Reject/replace non-conforming material and test replacement material
Grab Tensile Strength (ASTM D4632)	One per 40 rolls prior to installation	205 lbs	On-site material stockpile	Reject/replace non-conforming material and test replacement material
Trapezoidal Tear Strength (ASTM D4533 in machine and cross-machine directions)	One per 40 rolls prior to installation	85 lbs	On-site material stockpile	Reject/replace non-conforming material and test replacement material
Puncture Strength (ASTM D6241)	One per 40 rolls prior to installation	535 lbs	On-site material stockpile	Reject/replace non-conforming material and test replacement material
Apparent Opening Size (mm) ASTM D 4751	One per 40 rolls prior to installation	0.18 mm Max	On-site material stockpile	Reject/replace non-conforming material and test replacement material
Permittivity (ASTM D4491)	One per 40 rolls prior to installation	1.3 sec ⁻¹	On-site material stockpile	Reject/replace non-conforming material and test replacement material

Notes:

- ¹ The required properties specified herein may be revised by the Engineer to reflect new or revised test methods or to conform with improvements to the state-of-the practice.
- ² Number of specimens per test established in applicable test method unless otherwise noted
- ³ The CQA Team may elect to have the Project material sampled at the manufacturer's factory and shipped to an independent testing laboratory for conformance testing.

Table 7.
CQA Conformance Sampling and Testing Requirements for Separation Geotextile. (1, 2, 3, 4)

Weight (ASTM D5261)	One per 40 rolls prior to installation	12 oz./sq. yd. nominal	Sample Location	Reject/replace non-conforming material and test replacement material
Grab Tensile Strength (ASTM D4632)	One per 40 rolls prior to installation	315 lbs	On-site material stockpile	Reject/replace non-conforming material and test replacement material
Grab Elongation (ASTM D4632)	One per 40 rolls prior to installation	50 percent	On-site material stockpile	Reject/replace non-conforming material and test replacement material
Trapezoidal Tear Strength (ASTM D4533 in machine and cross-machine directions)	One per 40 rolls prior to installation	115 lbs	On-site material stockpile	Reject/replace non-conforming material and test replacement material
Puncture Strength (ASTM D6241)	One per 40 rolls prior to installation	850 lbs	On-site material stockpile	Reject/replace non-conforming material and test replacement material
Apparent Opening Size (maxARV) (ASTM D4751)	One per 40 rolls prior to installation	0.150 mm	On-site material stockpile	Reject/replace non-conforming material and test replacement material

Notes:

Nonwoven.

- ¹ The required properties specified herein may be revised by the Engineer to reflect new or revised test methods or to conform with improvements to the state-of-the practice.
- ² Number of specimens per test established in applicable test method unless otherwise noted.
- ³ The CQA Team may elect to have the Project material sampled at the manufacturer's factory and shipped to an independent testing laboratory for conformance testing.

Table 8.
CQA Conformance Sampling and Testing Requirements for GDN.⁽¹⁾

Property (Units)	CQA Sampling Frequency (minimum)	Test Method ⁽²⁾	Required Value
Finished HDPE Geonet			
Density (g/cc)	Every 500,000 ft ²	ASTM D 1505 or ASTM D 792	0.940 (min ave)
Thickness (mil)	Every 500,000 ft ²	ASTM D 5199	270.0 ± 15 (range) ⁽³⁾
Finished GDN⁽⁴⁾			
100- hr Transmissivity (m ² /sec)	Every 500,000 ft ²	ASTM D 4716	4.1 x 10 ⁻⁴ (MARV) ⁽⁵⁾
Ply Adhesion (lb/in)	Every 500,000 ft ²	ASTM D 7005	1.0 (MARV) ⁽⁶⁾⁽⁷⁾
Interface Shear Strength	Every 500,000 ft ²	ASTM D 5321	See Table 9 ⁽⁸⁾

Notes:

- ¹ The required properties specified herein may be revised by the Engineer to reflect new or revised test methods or to conform with improvements to the state-of-the practice.
- ² Number of specimens per test established in applicable test method unless otherwise noted.
- ³ Diameter of presser foot shall be 2.22 inches and pressure shall be 2.9 pounds per square inch. Lowest individual value = 255 mil.
- ⁴ Nonwoven geotextile heat-bonded to both sides.
- ⁵ Perform test using rigid platens for substrate and cover soil compacted per the specifications for the superstratum. Test conditions: Normal stress = 300 pounds per square foot; Hydraulic gradient = 0.25; Seating period = 100 hours.
- ⁶ MARV is statistically defined as mean minus two standard deviations and it is the value, which is exceeded by 97.5 percent of all the test data.
- ⁷ Average of five equally spaced tests across the roll width.
- ⁸ Lowest individual value = 0.5-pound per inch (lb/in).

Table 9.
Interface Shear Strength Testing Requirements for GDN. (1, 2, 3, 4)

Testing Set-Up		
Standard Test	Conditioning and Set-up:	Set up each test to match field placement orientation. Run all tests under wet conditions.
	Procedure A:	GDN against Geomembrane Substrate: Project Textured 40 Mil LLDPE Geomembrane Superstratum: Project GDN Displacement Rate: 0.04-ipm (maximum) Total Displacement: 2.5 inches (minimum)
	Procedure B:	GDN against Site Protective Cover Soil Substrate: Project GDN Superstratum: Site Protective cover soil at 90% Standard Proctor MDD ± 3% OMC Displacement Rate: 0.04-ipm (maximum) Total Displacement: 2.5 inches (minimum)
	Special Instructions:	None.
	Strength Requirements	
Normal Stress [Pounds per Square Foot (psf)]		Minimum Peak Shear Strength
150		20 Degrees
300		
600		
1000		

Notes:

- ¹ Test individual interfaces between Steel rasp platens. In lieu of testing individual interfaces, a system test may be performed using configuration that allows failure to occur through the weakest shearing plane. System test configuration, conditions, and procedures must be accepted by the Engineer prior to submitting test results for review and approval.
- ² Geosynthetics shall be oriented such that the shear force is parallel to the down slope orientation of these components in the field.
- ³ Interfaces shall be saturated for a minimum of 24 hours prior to testing.
- ⁴ Testing to be performed in accordance with ASTM 5321 utilizing the test conditions and procedures outlined. GDN is not acceptable if geotextile delaminates from the geonet, even if required strengths are attained.

Table 10.
CQA Conformance Sampling and Testing Requirements for Underdrain Geotextile.

Property (Units)	Testing Frequency (Minimum)	Test Method	Required Value
Structure	Hybrid Monolithic Woven-Nonwoven Needle-punched		
Mass per unit Area (oz./sq yd)	One per 40 rolls prior to installation	ASTM D 5261	14 (min)
Grab Tensile Strength (lb)	One per 40 rolls prior to installation	ASTM D 4632	200 (min)
Tear Strength (lb)	One per 40 rolls prior to installation	ASTM D 4533	85 (min)
Puncture Strength (lb)	One per 40 rolls prior to installation	ASTM D 6241	775 (min)
Permittivity (sec-1)	One per 40 rolls prior to installation	ASTM D 4491	0.3 (min)
Apparent Opening Size (mm)	One per 40 rolls prior to installation	ASTM D 4751	0.088 (Max)

Table 11.
Test Procedures for the Evaluation of Aggregates.

Test Method	To Determine	Test Standard
Laboratory Test Procedures		
Sieve Analysis	Particle Size Distribution of Course-Grained Soils	ASTM D422 (wet) or ASTM C 136
Unified Soil Classification System (USCS)	USCS Textural Classification	ASTM D2487
Calcium Carbonate	To Determine Calcium Carbonate Content of Aggregate	ASTM D3042
Soundness	Determination of soundness of aggregates by use of sodium or magnesium sulfate	ASTM T104
Relative Density	Relative Density	ASTM D4253 ASTM D4254
Field Test Procedures		
Soil Description	Identification of Aggregate	ASTM D2488
Ruler, Scale or Elevation Reading	Lift Depths	--

Table 12.
Pre-Qualification Testing for Soils.

Test	Standard	Frequency	Material
Sieve Analysis With Hydrometer	ASTM D422	One per source or visual change	Protective Cover Soil, Vegetative Support, Structural Fill, Low Permeability Soil Liner
Atterberg Limits	ASTM D4318	One per source or visual change	Protective Cover Soil, Vegetative Support Soil, Structural Fill, Low Permeability Soil Liner
Unified Soil Classification	ASTM D2487	One per source or visual change	Protective Cover Soil, Vegetative Support Soil, Structural Fill, Low Permeability Soil Liner
Moisture/Density Relationship	ASTM D698	One per source or visual change	Subgrade Fill, Protective Cover Soil, Vegetative Support Soil, Structural Fill, Low Permeability Soil Liner, Common Fill
Permeability ⁽¹⁾	ASTM D5084	One per source or visual change	Low Permeability Soil Liner

Note:

- ¹ At 90 or 95 percent D698 maximum dry density (as determined by test pad) at optimum moisture content (OMC) to OMC +3 percent.

Table 13.
Requirements, Frequency, and Acceptance Criteria for Monitoring of Soils.

Item	Requirement	Minimum Test Frequency/Observation	Acceptance Criteria
1. Subgrade Fill	Verification of subgrade fill, including compaction equipment utilized	Visual observation	--
	Verification that Subgrade Fill containing CCRs is not placed beyond the Limit of Geosynthetic Cap System.	Visual observation	--
	Verification that unsuitable and contaminated materials are not in fill as stated in the specifications	Visual observation	--
	Lift Thickness (when prepared subgrade is fill)	Visual observation	2 foot (loose) maximum
2. Prepared Subgrade Surface	Proof-rolling.	Visual observation of the action of the compaction equipment (i.e., penetration, pumping, and cracking). Visual observation of surface condition of prepared subgrade of both cut and fill	No ruts deeper than 1 inch
	Verification that the final surface is smooth, uniform, and without large protrusions.	Visual observation of entire prepared subgrade surface	No ruts deeper than 1 inch; no protrusions greater than 3/8 inch, unless cushion geotextile used

Table 13 (Continued).

Item	Requirement	Minimum Test Frequency/Observation	Acceptance Criteria
3. Protective Cover Soil Layer	Unified Soil Classification	5H:1V slopes longer than 50 feet and 4H:1V area only: One test per acre and one test per soil type	5H:1V slopes longer than 50 feet and 4H:1V area only: CL or CH
	Maximum Particle Size	Continuous visual observation	4 inches – Test Pad may be used to demonstrate alternate acceptable particle size
	Atterberg Limits	5H:1V slopes longer than 50 feet and 4H:1V area only: One test per acre and one test per soil type	5H:1V slopes longer than 50 feet and 4H:1V area only: Plasticity Index > 15
	Field Density/Moisture Tests	5H: 1V slopes longer than 50 feet and 4H: 1V area only: Two in-place density tests per acre per lift. Minimum one test performed each day that cover is placed	5H: 1V slopes longer than 50 feet and 4H: 1V area only: 90 percent of standard proctor; +/- 3 percent OMC
	Lift thickness	Visual observation	The first lift shall be placed in a 14-inch loose lift, and the second lift sufficient to result in total compacted Protective Cover Layer thickness of 18 inches
4. Vegetative Support Layer	Maximum Particle Size	Continuous visual observation	6 inches
	Soil Fertility Testing	Vegetative Support Layer only, One test per 10 acres	Per Agronomist Recommendation
	Lift thickness	Visual observation	Compacted lift thickness of 6 inches. Total soil cover thickness 24 inches minimum

Table 13 (Continued).

Item	Requirement	Minimum Test Frequency/Observation	Acceptance Criteria
5. Structural Fill	Field Density/Moisture Tests	Four tests per acre per lift. Minimum one test performed each day that structural fill is placed	95 percent of ASTM D698 maximum dry density; +/- 3 percent OMC
	Standard Proctor Test	One test for each 40,000 cubic yards of structural fill material placed and one test for each type of material	--
	Atterberg Limits	Every time a Standard Proctor Test is performed	PI ≥ 7
	Unified Soil Classification	Every time a Standard Proctor Test is performed	SC, ML, or CL or be existing embankment or trench material which is being replaced
	Maximum Particle Size	Visual observation	2 inches
	Lift thickness	Visual observation	12-inch loose lifts, unless indicated otherwise
6. Common Fill	Field Density/Moisture Tests	Four tests per acre per lift of common fill. Minimum one test performed each day that fill is placed	90 percent of D 698 maximum dry density; +/- 3 percent OMC
	Standard Proctor Test	One test for each 40,000 cubic yards of common fill material placed and one test for each type of material	--
	Maximum Particle Size	Continuous visual observation	12 inch
	Lift thickness	Visual observation	12-inch loose lifts
	Maximum Particle Size	Visual observation	12 inches
7. Low Permeability Soil Liner	Standard Proctor Test	One test for each 3,000 cubic yards of cover soil material placed and one test for each type of material	--
	Unified Soil Classification	One per acre and one per soil type	CH or CL or reuse existing low permeability soil liner soil or other augmented compacted clays or soils
	Atterberg Limits	One test per acre and one per soil type	--
	Combustible Content	One test per acre	--
	Visual observation	2 inches	Maximum Particle Size

Table 13 (Continued).

Item	Requirement	Minimum Test Frequency/Observation	Acceptance Criteria
7.Low Permeability Soil Liner (continued)	Field Density/Moisture Tests	Two in-place density tests per acre per 12-inch lift. Minimum three tests performed each day that low permeability soil liner is placed	At percent D 698 maximum dry density and MC determined by test pad.
	Test Pad	One per soil source	Permeability less than or equal to 1×10^{-7} cm/sec at percent D 698 maximum dry density and MC determined by test pad.
	Permeability	One per acre and one per soil type	Permeability less than or equal to 1×10^{-7} cm/sec determined by in place testing
	Lift thickness	Visual observation	8-inch lift thickness

Note:

- ¹ Test Methods and Standards are listed in Table 12 of this CQA Plan. Sample size and location are given in the Test Standards. Corrective action if test fails is specifically listed under sections entitled "Conformance Test Failure" or generally to remove, replace or recompact until acceptance.

Surface Impoundment Closure Specifications Issued for Permit

Virginia Electric and Power Company
Possum Point Power Station
Coal Combustion Residuals Surface Impoundment Closures
Dumfries, Virginia

GAI Project Number: C150132.00
December 2015



Prepared by: GAI Consultants, Inc.
Richmond Office
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Prepared for: Dominion Resources Services, Inc.
5000 Dominion Boulevard
Glen Allen, Virginia 23060-3308

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SECTION 01000

Summary of Work

Section 01000 Summary of Work

Part 1 General

1.01 Project Description

- A. The Project: The Project consists of providing all labor, supervision, materials, tools, equipment, and any/all incidental services necessary for the construction of the **Possum Point Power Station Coal Combustion Residuals (CCRs) Surface Impoundment Closures**.
- B. Project Location: Dumfries, Virginia (VA)
Owner: Virginia Electric and Power Company
- C. Engineer Identification: The Contract Documents were prepared for the Project by:
GAI Consultants, Inc.
Richmond Office
4198 Cox Road, Suite 114
Glen Allen, VA 23060
- D. Work Summary: The work to be performed under these contract documents includes, but is not necessarily limited to, the following summary, which is neither a complete or sequential listing of the work items:
 - 1. Mobilization.
 - 2. All submittals. (Including critical submittals that are for items that require long lead time and could delay Contract and milestone completion).
 - 3. Limit transport of materials and construction activities as necessary to satisfy required limitations within the Eagle Nest Buffer Zones, as shown on Sheet 003.
 - 4. Furnishing, installing, and maintaining temporary erosion and sediment control measures.
 - 5. Locating and protecting existing utilities, structures and other facilities/property.
 - 6. Surveying existing conditions as required and providing construction stakeout.
 - 7. Removing existing pipes, structures, and appurtenances, as required where they exist within the work limits.
 - 8. Clearing trees, stumps, roots, brush, and other debris within the work limits and disposing of offsite.
 - 9. Dewatering of CCR Surface Impoundments
 - 10. Furnishing, installing, operating, maintaining, and removing pumps and pipelines for conveying subsurface dewatered effluent and contact water from CCR Surface Impoundments A, B, C, D, and E.
 - 11. Furnishing, installing, operating, maintaining, and removing pumps and pipelines for diverting non-contact water around Surface Impoundments A, B, C, D, and E during construction.

12. Sampling of water to ensure treatment systems meet discharge criteria.
13. Excavation and on-site (prior to October 19, 2015) or offsite disposal at a permitted facility (after October 19, 2015) of CCRs (coal combustion fly ash and bottom ash).
14. Excavating, hauling, processing, moisture conditioning, placing, compacting, and protecting earth fill and CCR material, as required.
15. Control and handling of groundwater, seeps, subsurface water, and contact water during excavation.
16. Furnish and install geotextile, drainage aggregate and perforated HDPE pipe in underdrains beneath the geosynthetic cap system as required to discharge CCR drainage during and after construction.
17. Fine grading and proof rolling to prepare subgrade surface.
18. Furnishing and installing cushion geotextile, if necessary.
19. Furnishing and installing textured 40-mil linear low density polyethylene (LLDPE) geomembrane liner.
20. Furnishing and installing geocomposite drainage net with geotextiles heat-bonded to both sides (GDN).
21. Furnish and install nonwoven filter geotextile, drainage aggregate and perforated high density polyethylene (HDPE) pipe in the subsurface drain system above the geosynthetic cap system.
22. Furnishing and installing stormwater controls, including pond embankments, riser structures, soil stormwater diversion berms, culverts, stormwater piping, inlet and outlet protection, channels, and drainage inlets. Provide and install channel linings as shown on the construction drawings.
23. Excavate, process, place, and compact protective cover soil over geosynthetic cap system without damage to geosynthetics.
24. Excavate, process, amend, and place vegetative support layer of the soil cover to remove large items and thoroughly incorporate soil amendments to produce a fully vegetated soil cover.
25. Providing positive drainage and temporary and permanent seeding of capped and disturbed areas, including borrow areas within the limits of disturbance.
26. Construct pipeline, manholes, valves, and appurtenances to convey discharge from the Power Plant's Oily Waste Pond (Internal Outfall 502) to the Plant's Low Volume Settling Ponds.
27. Sanitary Sewer Pipeline Relocation and Construction, including coordination with the Owner to schedule and perform the work with minimal impact to Station Operations.
28. Constructing perimeter and internal access roads and related guide rails and drainage features as required.
29. Quality Control System: review of submittals, surveys, observations, testing, and preparation of testing reports for geosynthetic materials.

30. Quality Control System: Coordination with the Owners Construction Quality Assurance (CQA) Team to ensure proper testing and construction of site soils, CCRs, and concrete.
31. Quality Control System: Coordination with the Owners CQA Team to ensure proper conformance testing and installation oversight of geosynthetics.
32. Prepare a Hurricane Protection Plan; Dam Breach Plan; and Spill Prevention, Control and Countermeasures (SPCC) Plan that demonstrates the Contractor's procedures and response plans in the event of a Hurricane, Dam Breach, or spill during the construction period.
33. Surveying and Record Documents (as-builts) including conformance surveys for prepared subgrade surface (Surface Impoundment D), limits of geosynthetic cap system, permanent surface and subsurface drainage structures/pipes, restored borrow areas, Phase 1 excavation grades (Surface Impoundments A, B, C, and E) and Phase 3 final grades for all Surface Impoundments including verification of the minimum 24-inch soil cover depth in Surface Impoundment D.
34. Daily maintenance of roads used during construction.
35. Daily dust control.
36. Maintaining and submitting acceptable Contractor's Daily Construction Reports as required herein.
37. Stormwater basins cleanup and sediment (unsuitable material) offsite disposal after project completion.
38. Site cleanup.
39. Post Construction Maintenance.
40. Demobilization.

1.02 Work Sequence

- A. Contractor shall be solely responsible for coordination of all the work to meet the requirements of the Contract Documents for all Phases of work within each Surface Impoundment.
- B. The Contractor is responsible for scheduling and sequencing the work to complete the work within the timeframe, milestones, substantial completion, and final completion dates required by the Contract Documents.
- C. Prior to Notice to Proceed, the Contractor is responsible for submitting a construction activities schedule to be approved by the Owner's Representative. Contractor shall phase water treatment, dewatering, excavation, fill, geosynthetic cap system construction, soil cover construction, stormwater management system, and placement of piping and other features as required in these Contract Documents in a logical and efficient order.
- D. The work shall minimize moving, hauling, and stockpiling of materials, avoid the deployment, placement, and welding of geosynthetic materials during periods of inclement weather, provide protection of geosynthetic and soil material during and after placement and testing, and minimize the need for rework or re-testing of elements that have been previously completed but have not been properly protected.

- E. The work shall be completed according to the Phasing plans shown on the construction drawings. The Contractor may submit a plan for approval by the Owner's Representative to further subdivide the proposed phasing or proposed a different phasing plan to complete the work.

1.03 Interpretation of the Contract Documents

- A. The Owner's Engineer is responsible for interpreting the Contract Documents. The Owner's Engineer interpretation shall be consistent with the intent that can be reasonably inferred from the Contract Documents, in their entirety. In case of conflicts within the Contract Documents or between the Contract Documents and other referenced standards or specifications, the Contractor shall notify the Owner's Representative immediately and any necessary changes shall be adjusted as provided in the contract for changes in the work. If the Contractor performs any work knowing such differences occur, or that the work is contrary to any laws, ordinances, rules and regulations, and without such notice to the Owner's Representative, he shall bear all cost arising there from.
- B. Reference to Standard Specifications: Reference to standard specifications such as ASTM International, American Nation Standards Institute, American Water Well Association, etc., shall be the specification in effect at the date of advertisement unless otherwise stated.
- C. Intent of Drawings:
 - 1. The drawings are intended to show general features and locations of piping, equipment, fixtures and specialties, and do not necessarily show all required offsets and details. All work shall be accurately laid out with reference to the drawings and in cooperation with other trades to avoid conflicts and to obtain a neat and workmanlike installation.
 - 2. The drawings are not intended to be rigid in specific details and where they may be in conflict with requirements of the other drawings, or of any applicable code or ordinance, or with recommendations of the manufacturers of any equipment actually furnished, installed or connected, the work hereunder includes the making of such adjustments as may be required to cause all such equipment to be installed and connected in conformance with such codes, ordinances or recommendations for the safe, proper and efficient operation of the equipment as approved by Owner's Engineer.

1.04 General Paragraphs

- A. Tools, Plant, and Equipment: If at any time before the commencement or during the progress of the work, tools, plant or equipment appear to the Owner to be insufficient, inefficient, or inappropriate to secure the quality of the work required or the proper rate of progress, the Owner may order the Contractor to increase their efficiency, to improve their character, to augment their number or to substitute new tools, plant, or equipment as the case may be, and the Contractor must conform to such order, but the failure of the Owner to demand such an increase of efficiency, number or improvement shall not relieve the Contractor of his obligation to secure the quality of work and the rate of progress necessary to complete the work within the time allowed and to the satisfaction of the Owner.
- B. Maintenance of Service, Prior Use by Owner: All existing utilities, both public and private, including sewer, gas, water, electrical services, etc., shall be protected and their operation shall be maintained throughout the course of the work. Any temporary shutdown of an existing service shall be arranged between the Contractor and the responsible agency. The

Contractor shall assume full responsibility and hold the Owner harmless from the result of any damage that may occur as a result of the Contractor's activities. Prior to completion of the work, the Owner (by agreement with the Contractor) may take over the operation and/or use of the completed project or portions thereof. Such prior use of facilities by the Owner shall not be deemed as acceptance of any work or relieve the Contractor from any of the requirements of the Contract Documents.

C. Codes, Laws, and Regulations:

1. It is intended that all work to be performed be in compliance with the latest editions of all applicable federal, state, and local codes, laws and regulations governing standards of design, construction workmanship, materials, types of equipment, and methods of installation in Prince William County, VA. If the Contractor performs any work knowing it to be contrary to such laws, ordinances, rules and regulations, and without such notice to the Owner's Representative, he shall bear all cost arising therefrom.
2. It shall be the Contractor's responsibility to comply with the Erosion and Sediment Control Plan for the Project and to otherwise comply with the Erosion and Sediment Control Law.

D. Safety and Health Requirements:

1. The Contractor shall comply with the Department of Labor's Safety and Health Requirements for construction promulgated under the Occupational Safety and Health Act of 1970 (PL 91-596) and under Section 107 of the Contract Work Hours and Safety Standards Act (PL 91-54) and all amendatory requirements thereof.
2. The Contractor shall comply with all Owner's health and safety and accident reporting requirements as stated in the Dominion Contract.

Part 2 Products

Not used.

Part 3 Execution

Not used.

-End of Section-

SECTION 01350

Submittals

Section 01350

Submittals

Part 1 General

1.01 General Paragraphs

- A. Contractor shall submit for the approval of the Owner's Representative, prior to start of construction, details or shop drawings, and manufacturer's specifications of all materials and equipment he intends to furnish under or as part of this project.
- B. All submittals shall be provided in digital format such as Adobe Acrobat (PDF) or other approved program and electronically sent the Owner's Representative; a hard copy of each submittal shall be received by the Owner's Representative within 5 days of the digital version.
- C. Equipment shall not be fabricated, ordered, or delivered until submittals and shop drawings have been approved.
- D. No portion of the work requiring submission of shop drawings, product data, or sample shall commence until the submittal has been approved by the Owner's Representative. All such portions of the work shall be in accordance with approved submittals.
- E. For substances that are proposed for use in the project that may be hazardous to human health, the Contractor shall submit to the Owner's Representative, for information only, information on precautions for safety using these substances, including Manufacturer's Safety Data Sheets (MSDS's), certification of registration by the Contractor with authorities under the respective Virginia and Federal Toxic Substances Control Acts.
- F. All deliveries shall be accompanied with a ticket or manifest indicating the origin of the shipment, the name of the manufacturer and supplier, a detailed description of the material/item(s) delivered, and the quantity of material/items delivered.
- G. Submit all delivery tickets within 48 hours of delivery or at least 48 hours before actual use of the material/item(s), whichever occurs first.
- H. Contractor shall submit to the Owner's Representative for approval, at least 21 days before procurement, a Certificate of Compliance from the manufacturer that the supplied materials or equipment meet the specifications.
- I. Shop drawings shall be accompanied with a certificate, signed by Supplier and Contractor, stating that products comply with the requirements of the relevant Specifications.
- J. Provide a separate submittal for each product specified herein. Do not combine multiple products in a single submittal, unless approved specifically by the Owner's Representative.
- K. Each Submittal shall contain only information relevant to the section and/or requirement for which the submittal is made. Extraneous information and literature shall be removed.
- L. When submitting manufacturer's information or catalog cuts, highlight the particular product for which the submittal is made using arrows, color, and underlining, to make the submittal clear.
- M. Each submittal shall be accompanied by a cover sheet which contains the following information:

1. Project Name.
 2. Contractor's name.
 3. Supplier.
 4. Material submitted.
 5. Applicable Specifications Section(s).
 6. Applicable Plan Sheet(s).
 7. Date of Submittal.
 8. Submittal Number.
 9. Identify whether submittal is a new submittal or re-submittal.
 10. Statement and signature indicating relevance and approval by the Contractor.
- N. The Contractor shall utilize a 10 character submittal identification numbering system for all material and equipment submittals including drawings, cut sheets, and manufacturer's information in the following manner:
1. The first character shall be an S.
 2. The next five digits shall be the applicable specification section number.
 3. The next three digits shall be the numbers 001 – 999 to sequentially number each separate item or drawing submitted under each specific section number.
 4. The last character shall be a letter, A-Z, indicating the submission or resubmission of the same drawing, e.g., A = first submission, B = second submission, C = third submission, etc. A typical submittal number would be as follows:
S-02200-008-B

S Submittal

02200 Specification Section for Earthwork

008 The eighth different submittal under this specification

B The second submission (1st resubmission) of that particular submittal
- O. The Contractor shall direct specific attention, in writing, or on resubmitted shop drawings, product data, or samples, to revisions other than those requested by the Owner's Representative on previous submittals.
- P. The cover sheet for each shop drawing submittal shall contain a blank space, at least 4" square, for the Owner's Representative approval.
- Q. The Contractor's Responsible Party shall coordinate, review, and approve all submittals prior to submission to Owner's Representative.
- R. Approval of the Contractor's shop drawings will be general and shall not relieve the Contractor from the responsibility for adherences to the Contract Document, nor shall it relieve him of the responsibility for any errors, which originated with the submittal. Where such errors or omissions are discovered later, they shall be corrected by the Contractor at no additional cost, irrespective of any approval by the Owner's Representative or Owner's Engineer.

S. Owner's Representative / Owner's Engineer review time shall be as follows:

Material and sample submittals: 7 days

Shop drawings: 10 days

Record documents: 10 days

Test results: 10 days

Schedules: 10 days

Conformance Surveys: 10 days

Request for Information/Clarification: 10 days

T. Submit a Record (Log) of Submittals, to the Owner's Representative prior to construction and an updated log before each progress meeting. The Submittal Log shall include all submittals anticipated for the Work, based on the Contract Documents, in their entirety.

U. All items, information, requests, and documents transmitted by the Contractor to the Owner's Representative shall be considered submittals and shall be submitted in accordance with this section.

Part 2 Products

Not used.

Part 3 Execution

Not used.

-End of Section-

SECTION 01400

Construction Requirement Services and Temporary Facilities

Section 01400

Construction Requirement Services and Temporary Facilities

Part 1 General

1.01 Summary

The requirements of this Section apply to, and are a component of, each section of the specifications. The Contractor is responsible for furnishing all labor, equipment, materials, and provisions to provide temporary facilities and controls, including but not limited to the Owner Representative's/Owner Engineer's/Construction Quality Assurance (CQA) Consultant's and Contractor's field offices, Contractor's storage area(s), utility connections/hookups and permits for water service, electrical service, telephone service, maintenance of traffic, barricades, fences, damage to existing property, security, access roads, drainage, parking, and emergencies.

1.02 Office Facilities

- A. Contractor shall provide and maintain a field office trailer for his onsite staff where shown on the Plans.
- B. Contractor shall provide and maintain a second temporary field office for the use of Owner's Representative, the Owner Engineer, and the Owner's QC Team.
- C. Contractor shall be responsible for obtaining all necessary permits for the trailers.
- D. Contractor shall provide his onsite Superintendent and his Project Manager with functional cellular telephones and email devices with access to the devices 24 hours per day, 7 days per week, including weekends and holidays.
- E. Copies of the Plans, Specifications, and other Contract Documents shall be kept at Contractor's office at the site of the work and available for use by the Contractor's employees and his subcontractors at all times.
- F. At a minimum, one copy of the Standard Handbooks and Specifications listed below shall be provided by the Contractor kept in the Owner/Engineer's office trailer for onsite use by all parties:
 - 1. Virginia (VA) Erosion and Sediment Control Handbook; current edition as of Bid Advertisement Date.
 - 2. VA Department of Transportation Road and Bridge Standards; current edition as of Bid Advertisement Date.
 - 3. VA Department of Transportation Road and Bridge Specifications; current edition as of Bid Advertisement Date.
 - 4. Prince William County's Design and Construction Standards Manual; current edition as of Bid Advertisement Date.
- G. Maintenance and Equipment. The Contractor shall provide the following for his trailer and the Owner's Representative's Trailer:
 - 1. Provide janitorial, cleaning, removal of waste, security services, and supplies once per week for the duration of the project.
 - 2. Drinking Water.

3. Copy Machine.
 4. Electric power, lights, heating and cooling.
 5. Three desks, three desk chairs, three side chairs, plan review table, large conference table and 15 chairs (for meetings).
- H. In the event the field office or appurtenant facilities are damaged or destroyed during the contract period due to Contractor's actions or negligence, the Contractor shall, at his expense, repair or replace the same to its original, like new condition.
- I. Contractor shall be responsible for all equipment in the office trailers, and shall make good, or replace in kind, at his own expense, any such equipment damaged or lost through fire, theft, and/or vandalism for the duration of this Contract.
- J. Contractor shall maintain the existing parking area outside the office trailers in good condition.

1.03 Temporary Utilities

- A. Electric Power:
1. Contractor shall supply Class II emission portable electric generators of sufficient size to power the office trailers.
 2. Temporary electric power installations shall meet construction safety requirements of Dominion, Occupational Safety, and Health Administration, state, and other governing agencies.
 3. An electric pole with service feed is available in the Pond D Laydown Area.
 4. Cost of fuel for generators for electric power used during performance of the work shall be borne by the Contractor.
- B. Internet Access: Install broadband internet modem at the Owner's Representative office and coordinate with the internet service provider to connect and provide broadband internet service. Contractor shall pay any installation fees of establishing the Owner's Representative internet service and all fees associated with the internet service for the duration of the Contract.
- C. Water: Contractor is responsible for coordinating with water utility and obtaining water hookup and required permit for connection to nearby hydrant. Cost of water shall be paid for by Contractor.

1.04 Removal of Temporary Construction

- A. Remove temporary materials, equipment, services, and construction prior to final inspection.
- B. Clean and repair damage caused by installation or use of temporary facilities. Remove underground installations to a depth of 2 feet, grade site as required. Restore existing facilities used during construction to specified or original condition.
- C. Remove erosion and sediment controls at the direction of the Erosion and Sediment Control Inspector.

Part 2 Products

Not used.

Part 3 Execution

Not used.

-End of Section-

SECTION 01450

Dust Control and Air Compliance

Section 01450

Dust Control and Air Compliance

Part 1 General

1.01 Description of Work

- A. The Contractor shall employ construction methods and means that keep airborne particulates to the minimum and shall provide for the application of water or employ other appropriate preventive means or methods to maintain dust control, subject to the approval of the Owner.
- B. Dust control measures shall be compatible with existing on-site materials and proposed materials.
- C. The contractor shall comply with the Owner's air Permit Requirements.

1.02 Related Sections

- A. Site Preparation - 02100
- B. Earthwork - 02200
- C. Site Clearing and Grubbing - 02110

1.03 General Description of Air Permit Requirements

- A. Standards for Non-Road Engines:

Non-Road Engines are exempt from permitting. Contractor shall provide list of all engines for evaluation prior to mobilizing equipment onsite. Contractor shall track the time each Non-Road Engine arrives on site and is removed from the site and provide this information to the Owner's Representative on a weekly basis.

To qualify as a Non-Road Engines all of the following shall be met:

- ▶ Engine that is used in or on a piece of equipment that is self-propelled or serves a dual purpose by both propelling itself and performing another function (such as a garden tractor, off-road mobile cranes and bulldozers).
- ▶ Engine that is used in or on a piece of equipment that is intended to be propelled while performing its function (such as lawnmowers and string trimmers).
- ▶ By itself or in or on a piece of equipment it is portable or transportable, meaning designed to be and capable of being carried or moved from one location to another. Included but not limited to wheels, skids, carrying handles, dolly, trailer, or platform.

An internal combustion engine is not a non-road engine if it remains or will remain at a location for more than 12 consecutive months. Any engine or engines that replaces an engine at a location that are intended to perform the same or similar function as the engine replaced will be included in calculating the consecutive time period for the 12 month time requirement.

- B. Internal combustion engines that are not non-road engines (stationary engines):
 - ▶ If the engine holds a permit, the Contractor shall provide information so that the Owner may notify the VA DEQ 15-days before the engine arrives on site.

- ▶ As applicable, Contractor shall provide the Owner with documentation that the engines comply with the requirements of MACT ZZZZ, NSPS IIII, or NSPS JJJJ. The Owner will evaluate and approve documentation to make sure the engine meets the requirements of Station's air permit.
- C. All air emitting equipment should be reported to Dominion's environmental group for air permitting evaluations.
- D. Fuel Standards for Non-Road Engines:
 - ▶ Fuel for non-road diesel engines must have a sulfur content less than or equal to 15 parts per million (Ultra Low Sulfur fuel).
 - ▶ The storage tanks (including dispensers) containing the Ultra-Low Sulfur fuel must be properly labeled and permitted and installed according to the applicable SPCC requirements.
- E. Vehicle Idling Restrictions VA Requirement:
 - ▶ Licensed on-road motor vehicles restricted to no more than 3 minutes when parked in urban areas.
 - ▶ Exception for necessity to provide auxiliary power (i.e., a bucket truck's lift).
 - ▶ May not idle to provide heating or air conditioning.
- F. Fugitive Dust (9 VAC 5-50-90):
 - ▶ During the operation of a stationary source or any other building, structure, facility, or installation, do not permit any materials or property to be handled, transported, repaired, or demolished without taking reasonable precautions to prevent fugitive emissions (dust) from becoming airborne.
 - ▶ Use water to control dust. Examples include the demolition of structures, construction operations, stockpiles, dewatered CCR, grading of roads or clearing of land.
 - ▶ Stabilize or apply water on dirt roads, materials stockpiles and other surfaces which may create airborne dust.
 - ▶ Pave roadways as needed, and maintain them in a clean condition.
 - ▶ Adequate containment methods should be employed during sandblasting or similar operations.
 - ▶ Open equipment for conveying or transporting material likely to create objectionable dust shall be covered or treated in an equally effective manner at all times when in motion.
 - ▶ Promptly remove spilled or tracked dirt or other materials from paved streets. This also includes the removal of dried sediments resulting from soil erosion.
 - ▶ Chemicals may be proposed for dust control if water is not effective. Any chemical proposed for use for dust control must be approved by the Owner's Representative prior to use.

Part 2 Products

Not used.

Part 3 Execution

3.01 Dust Control

- A. During grading activities, soils and CCRs will be treated using wet suppression for dust control. Watering equipment shall be used to minimize airborne concentrations and shall consist of pipelines, tank trucks, or other devices approved by the Owner, which are capable of applying a uniform spread of water over the ground surface. A suitable device for a positive shut-off and for regulating the flow rate of water shall be located so as to permit positive operator control. Calcium chloride is not allowed for dust control.
- B. Minimize the exposed area of disturbed material.
- C. Depending on the expected weather conditions, exposed disturbed material may only be left exposed over night after wet suppression treatment and sealing with smooth drum roller.
- D. Stabilize exposed subgrade with wet suppression treatment and sealing with smooth drum roller if liner system is not installed in the same day.
- E. Site activities may be suspended if sustained wind speeds exceed 25 miles per hour or during adverse weather conditions.

-End of Section-

SECTION 01500

Project Record Documents

Section 01500

Project Record Documents

Part 1 General

1.01 Summary

- A. The purpose of the final Record Documents is to provide factual information regarding all aspects of the Work, both concealed and visible, to enable future modification of the design to proceed without lengthy and expensive site measure, investigation, and examination.
- B. The Contractor shall maintain at the site for the Owner's and Owner's Representative's permanent records two complete set of Record Documents which include a copy of the Contract Drawings, Contract Specifications, Addenda, Change Orders, Owner Field Orders, Shop Drawings, Quality Control Field Reports, Product Data, and Samples. The Contract Plans are to be used as Record Drawings by the Contractor.
- C. Submit three bound sets of Record Drawings to the Owner's Representative upon completion of the project. Employ the services of a licensed surveyor, licensed in the Commonwealth of VA, to prepare and seal the Record Drawings.
- D. The following record drawings shall be provided by the Contractor's Independent Surveyor.
 1. Existing conditions prior to starting contract work (Contractor may supplement and verify existing topographic mapping).
 2. Survey of Ash Placement in Surface Impoundment D after completion of Dredging A, B, C, and E.
 3. Phase 1 Grading – Surface Impoundments A, B, C, and E.
 4. Sanitary Sewer Relocation – Surface Impoundments A, B, and C.
 5. Phase 2 Grading – Surface Impoundments A, B, C, D, and E.
 6. Limit and thickness verification of existing constructed or natural Low Permeability Soil in Surface Impoundment D.
 7. Limit of GCL installation in Surface Impoundment D.
 8. Prepared Subgrade Surface – Surface Impoundment D.
 9. Underdrain Piping, Alignments, and Inverts – Surface Impoundment D.
 10. Temporary Sediment Ponds, Surface Impoundments B, C, and E - Principal Spillway Riser Crest, Barrel Inlet Invert Elev., Barrel Outlet Invert Elev., Emergency Spillway Crest, and Limit of Outlet Protection.
 11. Limit of Geosynthetic Cap System – Surface Impoundment D.
 12. LLDPE geomembrane panel layout and repair locations.
 13. Phase 3 Grading (Final Grades) – Surface Impoundments A, B, C, D, and E.
Include:
 - Grading
 - Channel Cross Sections

- Channel Profiles
 - Limit of Channel Lining Protection (Rip-Rap, Cellular Concrete Mattresses, Gabions, etc.)
 - Thickness verification for final cover system in Surface Impoundment D
14. Subsurface Drainage Piping Alignments, Inverts, Outlets, and Cleanout Locations – Surface Impoundment D.
 15. Piezometer and Vent Locations - Surface Impoundment D.
 16. Final Grading - Borrow Areas.
 17. Access Roads - Limits, Drainage Pipe/Culvert Inlet and Outlet Invert Locations and Elevations.
 18. Plugged/Grouted Existing Pipes.
 19. Fencing

1.02 Submittals

- A. At Contract closeout, submit Record Documents to Owner's Representative for the Owner.
- B. Accompany submittal with transmittal letter in duplicate, containing:
 1. Date
 2. Project title and number
 3. Contractor's name and address.
 4. Title and number of each Record Document.
 5. Signature of Contractor or his authorized representative.

Part 2 Products

2.01 Record Drawings

- A. Record Prints: Maintain one set of blue or black-line white prints of the Drawings and Shop Drawings.
 1. Preparation: Mark Record Prints to show the actual installation where installation varies from that shown originally. Require individual or entity who obtained record data, whether individual or entity is Installer, subcontractor, or similar entity, to prepare the marked-up Record Prints.
 - a. Give particular attention to information on concealed elements that would be difficult to identify or measure and record later.
 - b. Accurately record information in an understandable drawing technique. Record data on Drawing or log book as soon as possible after obtaining. Record and check the markup before enclosing concealed installations.
 2. Content: Types of items requiring marking include, but are not limited to, the following:
 - a. Dimensional changes to Drawings.
 - b. Revisions to details shown on Drawings.

- c. Locations and depths of underground utilities.
 - d. Revisions to routing of piping and conduits.
 - e. Details not on the original Drawings.
 - f. Field records for variable and concealed conditions.
3. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at the same location.
4. Mark important additional information that was either shown schematically or omitted from original Drawings.
- B. Record Drawings: Immediately before inspection for Certificate of Substantial Completion, review marked-up Record Prints with Owner's Representative. When authorized, prepare a full set of corrected prints of the Contract Drawings.
 1. Incorporate changes and additional information previously marked on Record Prints. Erase, redraw, and add details and notations where applicable.
- C. Format: Identify and date each Record Drawing; include the designation "PROJECT RECORD DRAWING" in a prominent location.

Part 3 Execution

3.01 Recording and Maintenance

- A. Recording: Maintain one copy of each submittal during the construction period for Project Record Document purposes. Post changes and modifications to Project Record Documents as they occur; do not wait until the end of Project.

-End of Section-

SECTION 02100

Site Preparation

Section 02100

Site Preparation

Part 1 General

1.01 Description of Work

- A. The Contractor shall furnish all materials, labor, equipment, tools, and appurtenances required to complete the work.
- B. Comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, state, or federal authorities having jurisdiction.
- C. Remove and dispose of all debris, bulky items, waste materials, etc. existing in the area to be constructed and encountered on the surface. All bulky items such as large debris, stumps, cars, old fencing, etc. are to be disposed off-site at Contractor's expense.
- D. Protect and maintain bench marks, monuments and other reference points. Re-establish, at no cost to the Owner, any such reference points if disturbed or destroyed. The Contractor's surveyor shall conduct a survey of all monuments and property markers within proposed cover areas prior to any disturbance such as they can be re-established after completion of the cover by the Contractor as part of this Contract.
- E. Remove, demolish, excavate, haul, and dispose of any on-site structures, pavement, roads, drainage pipes, utilities, etc. per Part 1.01C. above as shown on the Contract Drawings. Removal of on-site facilities shall be approved by the Owner's Representative prior to the work.

1.02 Related Sections

- A. Site Clearing and Grubbing - 02110
- B. Earthwork – 02200

Part 2 Products

Not used.

Part 3 Execution

Not used.

-End of Section-

SECTION 02110

Site Clearing and Grubbing

Section 02110

Site Clearing and Grubbing

Part 1 General

1.01 Description of Work

- A. The Contractor shall furnish all materials, labor, equipment, tools and appurtenances required to complete the work as described below. Contractor shall implement and supervise all work.
- B. Site clearing includes, but is not limited to, removing from the limits of work and disposing of trees, stumps, roots, brush, structures (at and below ground) including concrete riser and walkway, abandoned utilities, trash, asphalt, debris and all other materials found on or near the surface of the ground in the construction area. Precautionary measures that prevent damage to existing features to remain are part of the work.
- C. Comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, state, or federal authorities having jurisdiction.
- D. No clearing and grubbing will be allowed without adequate erosion and sedimentation control measures in place and to the satisfaction of the Owner or Owner's Representative.

1.02 Related Sections

- A. Erosion and Sediment Control - 02125
- B. Earthwork - 02200

1.03 Job Conditions

Location of the Work: The area to be cleared and grubbed includes all areas designated for cap construction, access road construction, channel construction, and required construction access areas.

Part 2 Products

The Contractor shall furnish equipment of the type normally used in clearing and grubbing operations including, but not limited to, dozers, shears, skidders, loaders, root rakes, chipping equipment and stump grinders.

Part 3 Execution

3.01 Scheduling of Clearing

- A. Contractor shall install all temporary Soil Erosion and Sedimentation Control Structures per Contractor's plan to the acceptance of Owner and Owner's Representative prior to start of clearing operations.
- B. Contractor shall maintain all survey controls.

3.02 Construction Area Clearing and Grubbing

- A. Materials to be cleared, grubbed, and removed from the construction areas include, but are not limited to, the following: all trees, stumps, roots, brush, trash, organic matter i.e. logs, root balls, etc., miscellaneous structures, debris, and abandoned utilities.

- B. Grubbing shall consist of completely removing roots, stumps, trash and other debris from all graded areas so that surface material is free of roots and debris. Surface material is to be left sufficiently clean so that further picking and raking will not be required.
- C. All stumps, roots, foundations, and debris embedded in the ground shall be removed and disposed.
- D. All construction areas shall be grubbed by tractors with root rakes.
- E. Where tree limbs interfere with utility wires, or where the trees to be felled are in close proximity to utility wires, the tree shall be taken down in sections to eliminate the possibility of damage to the utility. The Contractor shall be responsible for damages to utilities and shall replace/repair damaged utilities at no cost to Owner.
- F. Any work pertaining to utility poles and guy wires shall comply with the requirements of the appropriate utility.
- G. Stumps and roots shall be grubbed and removed to a depth of 18 inches below original grade. All holes or cavities which extend below the subgrade elevation of the proposed work shall be filled with crushed rock not larger than No. 57 aggregate or other suitable material, and compacted to a similar density as the surrounding material.
- H. The Contractor shall exercise special precautions for the protection and preservation of identified trees and shrubs with the construction area or those situated adjacent to the limits of the construction area. The Contractor shall be held liable for any damage the Contractor's operations have inflicted on such property.
- I. The Contractor shall be responsible for all damages to existing structures and/or improvements resulting from Contractor's operations.

3.03 Disposal of Debris

- A. All wood debris (stumps, roots, branches, and leaves) resulting from the clearing and grubbing operation shall be disposed of offsite or by other methods as approved by Owner's Representative, in accordance with the Drawings and Specifications.
- B. All large debris, pipe, large metal objects, and bulky items will be removed and hauled to an off-site approved disposal facility.

-End of Section-

SECTION 02125

Erosion and Sediment Control

Section 02125

Erosion and Sedimentation Control

Part 1 General

1.01 Description of Work

- A. The work shown on the Contract Drawings and Prince William County Approved Site Plan for the Project shall be considered a minimum requirement. What is shown shall not relieve the Contractor of the responsibility to actively take all steps necessary to control soil erosion and sedimentation control.
- B. The Contractor shall provide all materials and promptly take all actions necessary to achieve effective erosion and sedimentation control in accordance with all applicable federal, state, and local enforcing agency guidelines and these Specifications. Contractor shall provide a Certified Responsible Land Disturber (RLD) to implement and supervise all work.
- C. Comply with applicable codes, ordinances, rules, regulations and laws of Prince William County, and Commonwealth of Virginia.
- D. Contractor shall repair any material or existing surface conditions damaged by erosion or covered with sedimentation at the Contractor's expense.
- E. Contractor shall maintain at least 20 percent overstock of erosion control items stockpiled on-site for ease of use to replace installed items as deemed necessary, or provide evidence that necessary amounts of materials are readily available from local suppliers.
- F. The temporary erosion control features installed by the Contractor shall be maintained by the Contractor until no longer needed as determined by the Owner, or permanent erosion control methods are installed.
- G. It shall be the sole responsibility of the Contractor to properly schedule and coordinate all necessary labor, equipment, and materials such that the specified work is performed in accordance with the project schedule and the Contract requirements. At the discretion of the Owner, the Owner may reject or direct the Contractor to repair (at no cost to the Owner) those items which are detrimental to the project or not in compliance with the Contract Documents. Such direction or rejection by the Owner shall not relieve the Contractor of his obligation to properly schedule and perform other specified work items in conformance with the Contract Documents.

1.02 Related Sections

- A. Site Clearing and Grubbing - 02110
- B. Earthwork - 02200
- C. Drain Gravel/Coarse Aggregate - 02233
- D. Stone Riprap - 02271
- E. Geotextile - 02595
- F. Seeding - 02936

1.03 References

- A. Virginia Erosion and Sediment Control Handbook (VESCH), Third Edition, 1992.

1.04 Submittals

Submit product submittals for all erosion and sediment control products to be utilized at the site, upon request by the Owner's Representative.

The Contractor shall submit the manufacturer's product data, the installation manual, and maintenance information for erosion and sediment control geosynthetics.

Part 2 Products

Install the products in the locations shown on the plans and in accordance with requirements of Prince William County and the VESCH manual.

2.01 Silt Fence and Super Silt Fence

Silt fence shall be in accordance with the VESCH and Prince William County Requirements.

2.02 Bales

Silt fence shall be in accordance with the VESCH and Prince William County Requirements.

2.03 Seed

Seed type shall meet the requirements the VESCH and Section 02936 - Seeding.

2.04 Temporary Erosion Control Mat/Blanket

Temporary Erosion Control Mat/Blanket shall meet the requirements of EC-2 matting and be in accordance with the VESCH and Prince William County Requirements.

2.05 Permanent Erosion Control Mat/Blanket

Permanent Erosion Control Mat/Blanket shall meet the requirements of EC-3 matting and be in accordance with the VESCH and Prince William County Requirements.

Permanent Erosion Control Mat/Blanket EC-3 matting shall be Tensar/North American Green Vmax® P550® Turf Reinforcement Mat (TRM) or approved equal, and Tensar/North American Green Vmax® SC250® TRM or approved equal.

2.06 Sediment Filter Bags

Sediment Bags shall be in accordance with the VESCH and Prince William County Requirements.

2.07 Sediment Traps

Sediment Traps shall be in accordance with the VESCH and Prince William County Requirements.

2.08 Rock Check Dams

Rock Check Dams shall be in accordance with the VESCH and Prince William County Requirements.

2.09 Temporary Sediment Basins and Risers

Temporary Sediment basins and their apparatuses shall be in accordance with the VESCH and Prince William County Requirements.

Part 3 Execution

Refer to the Project's Prince William County Site Plan for Erosion and Sediment Control Requirements and Specifications.

The Contractor shall install E-3 matting in accordance with the manufacturer's installation manual.

The extent of Erosion and Sediment Control materials and methods shall be as shown on drawings.

-End of Section-

SECTION 02150

Construction Dewatering

Section 02150

Construction Dewatering

Part 1 General

1.01 Description of Work

- A. This section specifies the requirements for handling and management of dewatering activities.
- B. Contractor shall dewater existing Surface Impoundment D using rim ditches, well point systems, or other means approved by the Owner's Representative. Dewatering shall be completed for the duration of the project until the top 10 feet of CCR below the proposed subgrade elevation is dry or the CCR is sufficiently dewatered to allow for the installation of the geosynthetic cap. Active Dewatering using well points and Rim Ditches shall continue until the geosynthetic cap system is installed. Subsurface dewatered water and CCR contact water shall be pumped to the sanitary sewer or water treatment system to be installed in Surface Impoundment E, in accordance with the Owner's VPDES Permit VA0002071. Well points shall be cut off at a minimum of 5-feet below the geosynthetic liner and the pipe covered with regraded soil or CCR materials. If approved or requested by the owner's representative, select well points or dewatering wells may be booted through the geosynthetic cap system for continued dewatering and/or water level monitoring after the final cover system construction.
- C. The Contractor may install underdrains beneath the cap system as required to dewater the CCR during the construction process. Subsurface dewatering water, which is collected by any underdrain systems, shall be pumped to the water treatment system to be installed in Surface Impoundment E. After the geosynthetic cap system is installed, the underdrains may continue to operate as a passive dewatering system. Once the underdrains have dried up due to the sufficient dewatering of the CCR in the surface impoundment, the underdrains may be capped in place.
- D. Contractor shall design, construct, and maintain all dikes, sumps, and diversion and drainage channels as necessary to complete the construction and to protect the areas to be occupied by permanent work from water damage and divert non-contact water around the work area to the extent possible. Contractor shall remove temporary works after they have served their purpose.
- E. Contractor shall be responsible for the stability of all temporary and permanent slopes, grades, foundations, materials and structures during the course of the Contract. Repair and replace all slopes, grades, foundations, materials and structures damaged by water, both surface and subsurface, to the lines, grades, and conditions existing prior to the damage, at no additional cost to Owner.
- F. Contractor shall implement and supervise all Work.
- G. The Contractor shall submit a description of its methods for accomplishing construction dewatering to Owner and Owner's Representative for approval (Construction Dewatering Plan).
- H. Contractor shall provide measures to minimize accumulation of surface water in the work area.

1.02 Related Sections

- A. Erosion and Sediment Control - 02125
- B. Earthwork - 02200

Part 2 Products

Piping, pumping equipment, and all other equipment and materials required for dewatering shall be suitable for the intended purpose. Standby pumping units shall be maintained at the Site to be used in case of failure of the normal pumping units.

Part 3 Execution

3.01 Dewatering

- A. Design, furnish, install, maintain, monitor, operate, and remove necessary pumping and other equipment for dewatering the CCR surface impoundments and other parts of the Work and for maintaining the work areas free from water as required for constructing each part of Work.
- B. Install Dewatering System at surface impoundments A, B, C and E as required to dewater the CCR for removal of CCR from the impoundments. Install Dewatering System at Surface Impoundment D to dewater a minimum of the top 10 feet of CCR to create a stable workable CCR surface that can be graded, compacted, and capped with soil fill and geosynthetics.
- C. Furnish, install, operate, and maintain pumps and pipelines for conveying subsurface dewatering effluent and contact water from CCR Surface Impoundment A, B, C, and E to Pond D, the sanitary sewer, or a water treatment system in CCR Surface Impoundment E area.
- D. Furnish, install, operate, and maintain pumps and pipelines for diverting non-contact stormwater around CCR Surface Impoundments A, B, C, D and E during construction.
- E. Dewater by means which will enable completion of the Work and preserve final lines and grades. Do not disturb or displace adjacent soil.
- F. All pumping and drainage shall be done with no damage to property or structures and without interference with the rights of the public, owners of private property, pedestrians, vehicular traffic or the Work of other Contractors, and in accordance with all Federal, State, and local laws, ordinances and regulations.
- G. Do not overload or obstruct existing drainage facilities.
- H. After they have served their purpose, remove all temporary protective work at a time and in a manner approved by the Owner. All temporary diversion channels and other temporary excavations shall be cleaned out, backfilled and processed under the same specifications as those governing earthwork (Subgrade Fill and Soil Cover Layers).
- I. When the temporary works will not adversely affect any item of permanent work on the planned usage of the project, Contractor may be permitted to leave such temporary works in place. In such instances, breaching of dikes and other temporary works may be required.
- J. Pump all dewatering effluent and diverted surface water to the appropriate outfall and/or treatment system as directed by the Owner's Representative.

- K. By the use of pumps, siphons, tile drains or other approved methods, Contractor shall control the flow and accumulation of water in excavated areas to prevent excessive softening and disturbance of exposed soils in excavations as necessary for completion of the Work. The system used shall not cause settlement damage to adjacent structures. The Contractor shall carry out the Work by the use of other methods which will not endanger adjacent structures; all such Work shall be done at the no expense to the Owner.

-End of Section-

SECTION 02200

Earthwork

Section 02200

Earthwork

Part 1 General

1.01 Description of Work

This section includes technical requirements for excavation, as well as construction of the earthworks including Soil Cover Layers.

1.02 Related Work Specified Elsewhere

- A. Seeding - 02936
- B. Linear Low Density Polyethylene Geomembrane - 02597
- C. Geotextiles - 02595
- D. Geocomposite Drainage Net - 02590
- E. Erosion and Sediment Control - 02125
- F. Geosynthetic Clay Liner - 02598

1.03 Submittals

- A. Prior to the start of work, the Contractor shall submit a list of equipment to be used for fill placement and proof-rolling operations to the Owner's Representative for review and approval.

1.04 References

The following codes and standards are referenced in this Section:

- A. ASTM International (ASTM) Standards:
 - 1. ASTM C136, "Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates."
 - 2. ASTM D422, "Standard Test Method for Particle-Size Analysis of Soils."
 - 3. ASTM D698, "Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort."
 - 4. ASTM D2216, "Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass."
 - 5. ASTM D2487, "Classification of Soils for Engineering Purposes (Unified Soil Classification System)".
 - 6. ASTM D2488, "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)."
 - 6. ASTM D2937, "Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method."
 - 7. ASTM D4318, "Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils."
 - 8. ASTM D5084, "Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Material Using a Flexible Wall Permeameter."
 - 9. ASTM D6938, "Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)."

B. Geosynthetic Research Institute (GRI):

1. Guide GS11, "Standard Guide for Constructing Test Pads to Assess Protection Materials Intended to Avoid Geomembrane Puncture."

Part 2 Products

2.01 Material

2.01.1 Unsuitable Material

Unsuitable material for any earthwork shall be defined as ice, frozen material, liquids, organic matter, organic soil (peat), rubbish, litter, debris, rubble, wood, stumps, brush, root mass, leaves, metal, or trash. Unsuitable Material identified by the Contractor shall be approved by the Owner's Representative.

2.01.2 Coal Combustion Residuals (CCRs)

- A. CCRs consist of coal combustion fly ash and bottom ash. All site CCRs not disposed of offsite will be covered with a Geosynthetic Cap and Soil Cover or other erosion resistant cover.

2.01.3. Subgrade Fill

- A. The Subgrade Fill will be added soil and/or CCRs placed beneath the geosynthetic cap system as shown on the project drawings. Subgrade Fill shall not be placed beyond the limits of the geosynthetic cap system.
- B. The surface of the Subgrade Fill shall be proof-rolled in accordance with Section 3.07. The onsite source for Subgrade Fill shall be approved by the Owner's Representative prior to placement for each application. It shall be free of topsoil and unsuitable material as defined in Subsection 2.01.1.

2.01.4 Protective Cover Soil

- A. The bottom 18-inch thickness of the soil cover shall be on-site soils from the borrow area or dam embankment with a maximum particle size of 4 inches. It shall not contain CCRs or unsuitable material as defined in Subsection 2.01.1.

2.01.5 Vegetative Support Layer

- A. The top 6 inches of the 24-inch soil cover is the vegetative support layer. Soil material used as vegetative support layer material shall be on-site soils from the borrow area or dam embankment. It may be topsoil or amended Protective Cover Soil, and shall not contain CCRs or unsuitable material as defined in Subsection 2.01.1.
- B. The vegetative support layer shall not contain stones, lumps, roots, or similar objects larger than 6 inches in any dimension.
- C. Soil material used as the vegetative support layer must be capable of sustaining vegetation as specified in Section "Seeding". The vegetative support layer shall be amended as needed to support vegetation as specified in Section "Seeding".
- D. Vegetative Support Layer will not be used beneath roads or lined channels that will not be vegetated. For channels over the geosynthetic cap system, the combined thickness of Protective Cover Soil and channel linings will be a minimum of 24 inches.

2.01.6 Structural Fill

- A. Structural fill materials to be used for embankment construction of basins or ponds, foundation material for articulating concrete block mats or as designated on the drawings shall not contain topsoil, CCRs, or unsuitable or contaminated material as defined in Subsection 2.01.1. Structural fill material is described in Table 3. Structural fill for embankment use shall be approved by the Owner's Representative for each application.

2.01.7 Common Fill

- A. Common Fill shall be used for filling to the subgrade beyond the limit of the geosynthetic cap system and below the final grade of Surface Impoundments A, B, C, and E, and as shown on the Drawings. Common Fill shall consist of soil from onsite borrow areas, dam embankments or stockpiles. The onsite source for Common Fill shall be approved by the Owner's Representative prior to placement for each application. It shall have a maximum particle size of 12-inches and be free of CCRs, topsoil, and unsuitable materials listed in Subsection 2.01.1.

2.01.8 Low Permeability Soil Liner

- A. Soil liner material shall consist of clayey, low-permeability soils. The liner material shall have a coefficient of permeability of 1×10^{-7} cm/sec or less based on ASTM D5084 when compacted to the required density and at the required moisture content determined by the test pad. Suitable materials shall have the same USCS soil classification and similar grain size distribution and liquid and plastic limits as the test pad material that meets the required permeability, and be free of topsoil and CCRs, topsoil, and unsuitable material listed in Subsection 2.01.1. The material shall not contain particles having a maximum dimension greater than 2 inches.

Part 3 Execution

3.01 Test Pad

- A. The contractor shall construct a 50-foot by 50-foot by minimum 18-inch thick test pad constructed from low permeability soil liner soil material in an area as directed by the Engineer or Owner's Representative. The test pad shall be constructed using the Contractors proposed soil liner placement equipment including sheepsfoot compactor, bull dozer, and water truck. The purpose of the test pad is to establish a construction method which will yield an acceptable permeability of 1×10^{-7} cm/sec for each source and type of soil used for the low permeability soil liner. The test pad shall be compacted to a minimum of 95 percent of standard proctor density (ASTM D698) at optimum moisture content to +3 percent of the optimum moisture content. The soil for the test pad shall be placed in maximum 8-inch loose lifts and compacted. A water truck may be used for moisture control. The Contractor and QC Team shall report the construction method (number of passes, compaction equipment, etc.). Shelby tube samples shall be obtained from the top 12-inches of the test pad and these undisturbed Shelby tube samples shall be tested for permeability per ASTM D5084 by the QC Team. One Shelby tube sample shall be obtained from each half of the test pad. Upon approval of the test pad construction by the Owner's Engineer, the Contractor shall utilize the test pad construction method to construct the low permeability soil liner.
- B. Test pads may also be constructed following GRI GS11 to assess the potential for geomembrane puncture and to evaluate the need for a cushion geotextile.

3.02 Lines and Grades

- A. The Drawings indicate existing and proposed contours, as well as typical sections. The Contractor shall be responsible for the setting out of all cuts and fills required to complete the Work.
- B. The Drawings indicate reference survey control, which has been established by the Owner. The Work shall be located from this control by the Contractor.

3.03 Excavation

- A. Excavation shall conform to the lines and grades shown on the Drawings. Any deviation shall require prior approval of the Owner and Owner's Representative. Excavated areas shall be shaped and fine graded to provide a uniform surface free from windrows, bumps, hollows, and rock fragments. Topsoil shall be stripped and stockpiled from all excavated areas.
- B. The Contractor shall grade cut areas to provide positive drainage at all times. Any material which in the opinion of the Owner is rendered unsuitable due to the failure of the Contractor to maintain proper drainage shall be removed and disposed of as unsuitable material and replaced, at the Contractor's expense.
- C. Any over-excavation beyond the lines and grades shown on the Drawings that was not directed by the Owner or Owner's Representative shall be brought back to the designated grade(s) with approved material and compacted at the Contractor's expense.
- D. The Contractor shall maintain all Contractors haul roads which shall include the application of any dust suppressant to minimize fugitive dust. The dust suppressant used requires prior approval by the Owner.

3.04 Fill Placement

- A. All fill shall be placed in lifts (unless shown otherwise on the Drawings). Surfaces shall be provided with sufficient longitudinal and transverse slope to provide positive drainage of surface water.
- B. Structural Fill shall be placed in 8-inch loose lifts and compacted to a minimum density equal to 95 percent of the maximum dry density as determined by ASTM D698. The moisture content at the time of placement shall not vary from the optimum moisture content by more than 2 percent. The rock correction procedure shall be applied as indicated by the Owner's Representative.
- C. Low permeability soil liner materials shall be placed in maximum 8-inch loose lifts and compacted to a minimum required Standard Proctor Test (ASTM D698) dry density and moisture content of optimum to +3 percent or as determined by the test pad and approved by the Owner's Engineer. The minimum compacted liner thickness shall be one (1) foot. The rock correction procedure shall be applied as indicated by the Owner's Representative.
- D. Common Fill shall be placed in 12-inch loose lifts and compacted to a minimum density equal to 90 percent of the maximum dry density as determined by the Standard Proctor Test (ASTM D698). The moisture content at the time of placement shall not vary from the optimum moisture content by more than 3 percent or as determined by the Owner's Professional Engineer based on permeability test results. The rock correction procedure shall be applied as indicated by the Owner's Representative. If 6 to 12-inch sized rocks are encountered the Contractor shall space the rocks in a manner to allow proper compaction of the soil fill around each individual stone.

- E. Subgrade Fill shall be placed in maximum 24-inch loose lifts and compacted using equipment of the type and size to provide a firm subgrade for geosynthetic cap system placement. The compaction effort and method shall be approved by the Owner's Representative. If large rocks are encountered the Contractor shall space the rocks in a manner to allow proper compaction of the soil fill around each individual stone.
- F. Anchor trench (Geosynthetic Cap System termination) backfill and cover must be placed immediately after placement of the Geosynthetic Cap system. Anchor trench backfill is to be Protective Cover Soil placed or spread at a maximum lift thickness of 6 inches and compacted using equipment of the type and size required to produce 95 percent of Standard Proctor density. Compaction shall be performed in such a manner that no damage of the geosynthetic cap system occurs.
- G. Hauling equipment shall not be permitted to repeatedly follow a single track, but shall use different tracks each run in order to provide uniform compaction of the fill.
- H. No fill shall be placed while rain is falling unless approved by the Owner or Owner's Representative. Prior to resuming fill operations after rain, all muddy material shall be bladed off the surface to a depth necessary to expose firm compacted material.
- I. No fill shall be placed on frozen ground, and no frozen material shall be used for fill.
- J. At the end of the day's operation and when rain is threatening, the fill shall be sloped to provide positive drainage and shall be compacted over the entire cross-section and length with a smooth-drum roller to seal it against the entry of water.
- K. When the top of the fill or Prepared Subgrade Surface has dried out, become excessively wet, or been damaged by construction equipment, the surface on which additional fill or a structure is to be placed shall be scarified to a minimum depth of 6 inches, brought to the specified moisture content, and recompact to the specified density prior to the placement of additional fill, geosynthetics, or a structure.
- L. Fill which does not meet the requirements for moisture content at the time of compaction shall be dried or wetted to meet the specified requirements. If the fill material requires drying, this may be accomplished by reworking it under warm and dry atmospheric conditions. Water, if required, shall be added carefully by sprinkling and care should be taken that no more than the amount needed is applied. Ponding or flooding shall not be permitted.
- M. Where fill is not placed over geosynthetics, sheepfoot or segmented rollers that are capable of penetrating the full thickness of the lift shall be used to compact cohesive soils and smooth-drum vibratory rollers shall be used to compact granular materials unless otherwise approved. Rubber-tired rollers may be used to compact cohesive and non-cohesive materials with approval of the Owner's Representative.
- N. If screening is not performed on Protective Cover Soil, Contractor shall employ a minimum of three (3) people full time with skids to remove oversized material from the Protective Cover Soil and to help flatten wrinkles and prevent damage to geomembrane during placement of the first lift. If screening is performed on Protective Cover Soil, Contractor shall employ a minimum of one (1) person full time help flatten wrinkles and prevent damage to geomembrane during placement of the first lift.

3.05 Geosynthetic Cap System Subgrade Preparation

- A. The geosynthetic cap system subgrade shall be compacted to provide a firm subgrade for geosynthetic cap system installation. The compaction effort and method shall be approved by the Owner's Representative.
- B. The Contractor shall protect the completed Prepared Subgrade Surface from damage by equipment, trucks, or weather. Any damage to the Prepared Subgrade Surface shall be repaired at the Contractor's expense.
- C. The Subgrade Fill shall be placed in accordance with the Subgrade lines and grades shown on the Drawings which promote positive drainage. Any deviation in line and grade from that shown on the Drawings shall require prior approval of the Owner and Owner's Representative.
- D. After backfilling or cover placement, disturbed areas shall be fine graded to blend in with existing contours or to elevations as indicated on the Drawings. The finished areas will be left with puddle-free drainage.
- E. The Contractor shall be responsible for placing protective cover soil, structural fill and subgrade fill as necessary to create temporary stormwater diversion channels between construction sequences to protect the work. Stormwater Diversions shall be approved by the Owner's Representative and shall be constructed at no additional cost to the Owner.
- F. The prepared subgrade surface shall be smooth-drum rolled. The surface shall be worked by the Contractor so it is free of vegetation, large protruding rocks, fractured stone, debris, cobbles, rubbish roots, and sudden changes in slope. Objects shall protrude from the smooth surface no more than 3/8 inch, or as approved by the QC Team.

3.06 Soil Cover

- A. The minimum 24-inch Soil Cover shall consist of a minimum 18-inch thick layer of compacted Protective Cover Layer and a minimum 6-inch thick Vegetative Support Layer. The Protective Cover Layer shall be placed on directly over the GDN except where subsurface drainage is placed. The materials shall meet the requirements for Protective Cover Layer and Vegetative Support Layer as required in Section 2.01.3.
- B. Protective Cover Soil and Vegetative Support Layer Placement. No equipment shall be operated directly on the surface of geosynthetics without permission from the Owner's Professional Engineer. A 5 to 7 psi low ground pressure (LGP) dozer shall be used to place the Soil Cover layers over the geosynthetics layer. Cover material (soils, geotextiles, geocomposite, pipes, and aggregates) shall not be dropped onto the geomembrane or overlying geosynthetics from a height greater than 3 feet. Protective Cover Layer and Vegetative Support Layer soils shall be placed on the geosynthetics in an upward tumbling motion, and shall be placed from the bottom of the slope upward.
- C. Equipment placing Protective Cover Soil shall not stop abruptly, make sharp turns, spin their wheels or travel at speeds exceeding 5 mph. Protective Cover Soil shall be compacted with LGP dozers. Sheepsfoot rollers or other compaction equipment with protrusions that could penetrate the geosynthetics may not be used.
- D. A minimum thickness of 3 feet of Protective Cover Soil must be placed over the Geosynthetic Cap System prior to haulage truck traffic over the Geosynthetic Cap System.
- E. Tilling, discing, or other mixing of materials into the Vegetative Support Layer shall be performed without damaging underlying geosynthetics. The soil cover shall be placed within plus or minus 0.2-foot of the grades shown on the Drawings and thickness tolerance shall be plus 0.2-foot of the required thickness. Any deviation in line and grade from that

shown on the Drawings shall require prior approval of the Owner's Representative. Survey data shall be provided by a Licensed Professional Surveyor to verify the finished soil liner thickness as work progresses.

- F. Any portions of the soil cover that are determined to be unacceptable by the Owner or Owner's Representative prior to being covered by the overlying geosynthetics shall be removed and replaced or repaired at no additional cost to the Owner.
- G. To promote surface water runoff and reduce excessive drying, the Contractor shall prepare the working surface of the Cover Soil layers using a smooth drum roller as necessary. Prior to placement of additional fill material, the Contractor shall scarify smooth drum rolled surfaces to promote homogeneity between fill lifts.

3.07 Proof-Rolling

- A. Within the limits of the geosynthetic cap system installation, the Contractor shall proof-roll the final surface of the Subgrade Fill with at least two passes with approved heavy construction equipment. Unsuitable, soft areas or organic areas and protrusions greater than 3/8 inch shall be over-excavated until material acceptable to the Owner or Owner's Representative is encountered and backfilled with suitable compacted soil.
 - 1. Proof rolling shall be performed with a fully loaded tandem-axle truck or smooth drum roller approved by the Owner's Representative.
 - 2. Confined areas inaccessible to heavy compaction equipment shall be proof-rolled with a minimum of four passes with the largest practicable plate-compactor or walk-behind roller.
 - 3. Steep slopes, which pose an unsafe situation for rollers may be proof-rolled with tracked equipment and an approved towed roller capable of attaining the specified compaction requirements.
- B. All proof-rolling shall be performed in the presence of the Owner or Owner's Representative. Proof rolling shall take place after all cuts, fills, and fine grading are complete in the area.

Table 1
Test Procedures for the Evaluation of Soils

Test Method	To Determine	Test Standard
Laboratory Test Procedures		
Moisture Content	Moisture Content	ASTM D2216
Standard Proctor	Moisture/Density Relationship of Soil	ASTM D698
Hydrometer Analysis	Particle Size Distribution of Fine-Grained Soils	ASTM D422
Sieve Analysis	Particle Size Distribution of Course-Grained Soils	ASTM D422 (wet) or ASTM C136
Unified Soil Classification System (USCS)	USCS Textural Classification	ASTM D2487
Atterberg Limits	Plasticity Index	ASTM D4318
Field Test Procedures		
Nuclear Densimeter	Soil Density, Moisture Content	ASTM D6938
Sand Cone/Drive Cylinder (For Checking/Calibration Only)	Soil Density, Moisture Content	ASTM D1556 ASTM D2216 ASTM D2937
Soil Description	Identification of Soils	ASTM D 2488
Ruler, Scale or Elevation Reading	Soil Liner Thickness	--

Table 2
Pre-Qualification Testing

Test	Standard	Material	Frequency
Sieve Analysis With Hydrometer	ASTM D422	Protective Cover Soil, Vegetative Support Soil, Structural Fill, Low Permeability Soil Liner	One per source or visual change
Atterberg Limits	ASTM D4318	Protective Cover Soil, Vegetative Support Soil, Structural Fill, Low Permeability Soil Liner	One per source or visual change
Unified Soil Classification	ASTM D2487	Protective Cover Soil, Vegetative Support Soil, Structural Fill, Low Permeability Soil Liner	One per source or visual change
Moisture/Density Relationship	ASTM D698	Protective Cover Soil on 5H:1V slopes longer than 50 feet and 4H:1V slopes, Structural Fill, Low Permeability Soil Liner, Common Fill	One per source or visual change
Soil Fertility Testing	Per Agronomist recommendation	Vegetative Support Layer	One test per 10 acres
Permeability ⁽¹⁾	ASTM D5084	Low Permeability Soil Liner	One per source or visual change

Note:

- (1) At 90 or 95 percent D698 maximum dry density (as determined by test pad) at optimum moisture content (OMC) to OMC+3 percent.

Table 3
Monitoring of Soils

Item	Requirement ⁽¹⁾	Minimum Test Frequency/Observation	Acceptance Criteria
1. Subgrade Fill	Verification of subgrade fill, including compaction equipment utilized	Visual observation.	--
	Verification that Subgrade Fill containing CCRs is not placed beyond the Limit of Geosynthetic Cap System.	Visual observation.	
	Verification that unsuitable materials are not in fill as stated in the specifications	Visual observation.	--
	Lift Thickness (when prepared subgrade is fill)	Visual Observation	2-foot (loose) maximum.
2. Prepared Subgrade Surface	Proof-rolling.	Visual observation of the action of the compaction equipment (i.e., penetration, pumping, and cracking). Visual observation of surface condition of prepared subgrade of both cut and fill.	No ruts deeper than 1-inch
	Verification that the final surface is smooth, uniform, and without large protrusions.	Visual observation of entire prepared subgrade surface.	No ruts deeper than 1-inch. No protrusions greater than 3/8 inch ⁽²⁾ .
3. Protective Cover Soil Layer	Unified Soil Classification	5H:1V slopes longer than 50 feet and 4H:1V slopes only: One test per acre and one test per soil type	5H:1V slopes longer than 50 feet and 4H:1V slopes only: CL or CH
	Maximum Particle Size	Visual observation	4 inches ⁽³⁾
	Atterberg Limits	5H:1V slopes longer than 50 feet and 4H:1V slopes only: One test per acre and one test per soil type	5H:1V slopes longer than 50 feet and 4H:1V slopes only: Plasticity Index > 15
	Combustible Content	One test per acre	--
	Field Density/Moisture Tests	5H:1V slopes longer than 50 feet and 4H:1V slopes only: Two in-place density tests per acre per lift. Minimum one tests performed each day that cover is placed.	5H:1V slopes longer than 50 feet and 4H:1V slopes only: 90 percent of standard proctor; +/- 3 percent OMC
	Lift thickness	Visual Observation	The first lift shall be placed in a 14-inch loose lift, and the second lift sufficient to result in total compacted Protective Cover Layer thickness of 18 inches.
4. Vegetative Support Layer	Maximum Particle Size	Visual observation	6 inches
	Lift thickness	Visual Observation	Compacted lift thickness of 6 inches. Total soil cover thickness 24 inches minimum.

Table 3 (Continued)

Item	Requirement	Minimum Test Frequency/Observation	Acceptance Criteria
5. Structural Fill	Field Density/Moisture Tests	Four tests per acre per lift. Minimum one test performed each day that structural fill is placed.	95 percent of ASTM D698 maximum dry density; +/- 2 percent OMC
	Standard Proctor Test	One test for each 40,000 cubic yards of structural fill material placed and one test for each type of material.	--
	Atterberg Limits	Every time a Standard Proctor Test is performed.	PI ≥ 7.
	Unified Soil Classification	Every time a Standard Proctor Test is performed.	SC, ML, or CL or be existing embankment or trench material which is being replaced.
	Maximum Particle Size	Visual observation	2 inches
	Lift thickness	Visual Observation	8-inch loose lifts Unless indicated otherwise
6. Common Fill	Field Density/Moisture Tests	Four tests per acre per lift of common fill. Minimum one test performed each day that fill is placed.	90 percent of D 698 maximum dry density; +/- 3 percent OMC
	Standard Proctor Test	One test for each 40,000 cubic yards of common fill material placed and one test for each type of material.	--
	Maximum Particle Size	Visual observation	12 inch
	Lift thickness	Visual Observation	12-inch loose lifts

Table 3 (Continued)

Item	Requirement	Minimum Test Frequency/Observation	Acceptance Criteria
7. Low Permeability Soil Liner	Unified Soil Classification	One test per acre and one per soil type.	CH or CL or reuse existing low permeability soil liner soil or other augmented compacted clays or soils
	Maximum Particle Size	Visual observation	2 inch
	Standard Proctor Test	One test for each 3,000 cubic yards of cover soil material placed and one test for each type of material.	--
	Atterberg Limits	One test per acre and one per soil type	---
	Field Density/Moisture Tests	Two in-place density tests per acre per lift. Minimum three tests performed each day that low permeability soil liner is placed.	At percent D 698 maximum dry density and MC determined by test pad.
	Test Pad	One per soil source	Permeability less than or equal to 1×10^{-7} cm/sec at percent D 698 maximum dry density and MC determined by test pad.
	Permeability	One per acre and one per soil type.	Permeability less than or equal to 1×10^{-7} cm/sec determined by in place testing.
	Lift thickness	Visual Observation	8-inch lift thickness.

Notes:

1. Soil Testing will be completed by the QC Team in accordance with the Construction Quality Assurance Plan. Contractor shall coordinate with the CQA Team to ensure all testing is completed as required by these specifications.
2. Cushion Geotextile may be used to allow larger subgrade protrusion, as approved by Owner's Engineer.
3. Acceptable particle size may be re-evaluated using a test pad in accordance with GRI Guide GS11. Test pad geotextile above geomembrane may be replaced with GDN, as appropriate.

-End of Section-

SECTION 02233

Drain Gravel/Coarse Aggregate

Section 02233

Drain Gravel/Coarse Aggregate

Part 1 General

1.01 Description of Work

- A. The Contractor shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the work of furnishing, placing and compacting the stone as shown, specified or required. Contractor shall implement and supervise all work.
- B. Comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, state, or federal authorities having jurisdiction.

1.02 Related Sections

- A. High Density Polyethylene (HDPE) Pipe and Fittings - 02620
- B. Geotextile - 02595

1.03 References

The following codes and standards are referenced in this Section:

- A. American Association of State and Highway Transportation Officials (AASHTO)
 - 1. AASHTO T104, "Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate"
- B. ASTM International (ASTM) Standards:
 - 1. ASTM C136, "Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates"
 - 2. ASTM D422, "Standard Test Method for Particle-Size Analysis of Soils"
 - 3. ASTM D2487, "Classification of Soils for Engineering Purposes (Unified Soil Classification System)"
 - 4. ASTM D2488, "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)"
 - 5. ASTM D3042, "Standard Test Method for Insoluble Residue in Carbonate Aggregates"
 - 6. ASTM D4253, "Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table"
 - 7. ASTM D4254, "Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density"

Part 2 Products

2.01 Material

- A. The material shall be clean, sound, tough, durable, angular, subangular, and free from slag, cinders, ashes, rubbish, or other deleterious material in accordance with VDOT Section 203. Subangular and angular aggregate shall be as defined in ASTM International D2488 entitled "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)".

- B. Aggregate shall be stored in designated areas approved by the Owner. The Contractor is responsible for maintaining the stone free of contamination, and any stone determined by the Owner to be contaminated shall not be incorporated into the work.
- C. Coarse Aggregate for access road and drainage pipe bedding shall meet the gradation requirements for Virginia Department of Transportation coarse aggregate for the stone size(s) shown on the Construction Drawings.

2.02 Testing

- A. The Contractor shall submit to the Owner's Representative and Owner for approval, certification that the materials proposed for use as coarse aggregate comply with VDOT Section 203 specifications for the proposed application. The certification shall include, but not necessarily be limited to testing or certification of testing provided by the supplier.
- B. Underdrain aggregate shall be tested for calcium carbonate content in addition to VDOT aggregate requirements. Soluble carbonate shall not exceed 10 percent by weight.
- C. Additional conformance testing may be required by the Owner's Representative/Construction Quality Assurance (CQA) Consultant as specified in the CQA Plan.
- D. No material shall be placed unless approved by Owner's Representative.

Part 3 Execution

3.01 Placement

- A. Coarse aggregate shall be placed to the lines, depths, and grades as shown on the Drawings.
- B. Backfilling of coarse aggregate shall be performed by the Contractor in a manner such that the material is kept clean and free of foreign materials.
- C. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe.
- D. Pipe bedding and backfill shall be compacted with a minimum of three passes with a plate tamper. A minimum of 14 inches of fill shall be placed over the top of the pipe before trafficking can occur. The compaction effort shall be applied to both the bedding and the backfill around the pipes. The method of compaction shall not damage the pipe, geotextile or the geomembrane.
- E. The Owner's CQA Consultant will at any time inspect the stone in the trenches or in stockpile on-Site for contamination and, if necessary, reject all or portions of the stone.
- F. The Contractor shall use extreme care in the placing of the material over geosynthetics. The material shall be placed in a manner to maintain a minimum thickness of 12 inches between the geosynthetics and the spreading equipment. All coarse aggregate, placed within the limits of the geosynthetics, shall be placed by low pressure equipment. Equipment with ground pressure less than five pounds per square inch (psi) may travel on a minimum 12-inch thick drain gravel layer over the geosynthetic cap system. Equipment with a ground pressure equal to or greater than five psi must travel on a minimum 36-inch thick layer over the geosynthetic cap system.

Table 1
Test Procedures for the Evaluation of Aggregates

Test Method	To Determine	Test Standard
Laboratory Test Procedures		
Sieve Analysis	Particle Size Distribution of Course-Grained Soils	ASTM D422 (wet) or ASTM C 136
Unified Soil Classification System (USCS)	USCS Textural Classification	ASTM D2487
Calcium Carbonate	To Determine Calcium Carbonate Content of Aggregate	ASTM D3042
Soundness	Determination of soundness of aggregates by use of sodium or magnesium sulfate	AASHTO T104
Relative Density	Relative Density	ASTM D4253 ASTM D4254
Field Test Procedures		
Soil Description	Identification of Aggregate	ASTM D2488
Ruler, Scale or Elevation Reading	Lift Depths	--

Table 2
Pre-Qualification Testing

Test	Standard	Material	Frequency
Sieve Analysis of Aggregates	ASTM C136	VA Department of Transportation (VDOT) #57	One per source
		VDOT Fine Aggregate A	
		VDOT #1	
		VDOT #2	
		VDOT #3	
		VDOT #21B	
		VDOT #8	
Relative Density	ASTM D4253 ASTM D4254	VDOT #57	One per source
Calcium Carbonate	ASTM D3042	VDOT #57 (Underdrain only)	One per source
Soundness of Aggregates	AASHTO T104	VDOT #57	One per source
		VDOT Fine Aggregate A	
		VDOT #2	
		VDOT # 2	
		VDOT # 3	
		VDOT # 21B	
		VDOT #8	

-End of Section-

SECTION 02271

Stone Riprap

Section 02271

Stone Riprap

Part 1 General

1.01 Description of Work

- A. The Contractor shall provide all labor, materials, equipment, tools and appurtenances required to complete the work of furnishing and placing stone riprap, as shown, specified or required.
- B. Comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, state, or federal authorities having jurisdiction.

1.02 Related Sections

- A. Erosion and Sedimentation Control - 02125
- B. Geotextiles - 02595

Part 2 Products

2.01 Material

- A. Stone riprap and bedding shall consist of hard, durable, subangular material. It shall be free from any considerable amount of flat, laminated, or elongated particles; and shall be free from cracks, overburden shells, clay, organic matter, or other deleterious matter.
- B. The riprap shall be composed of Class A1, I or II riprap, as shown on the drawings
- C. The breadth or thickness of a single stone shall not be less than one-third its length.
- D. Bedding layer for Class II riprap shall be VDOT No. 1 coarse aggregate.

2.02 Submittals

Submit manufacturer's certification of material properties as outlined in Part 2.01 to the Owner's Representative.

Part 3 Execution

3.01 Installation – Loose Riprap

- A. Bedding for Class II riprap shall be placed to a thickness of 10 inches.
- B. Stone riprap shall be placed to thicknesses as indicated on Contract Drawings.
- C. Riprap shall be placed on Separation Geotextile as specified in Section 02595. The edges of the geotextile shall be sufficiently anchored to prevent movement during rock placement.
- D. Stone riprap shall be placed in a manner that will not damage geotextile, synthetics, utilities or other facilities. Riprap shall not be dropped from a height exceeding 3 feet.
- E. The tolerance in riprap thickness in place shall be -0 to +0.3-foot.
- F. No material shall be placed unless approved by the Owner.

-End of Section-

SECTION 02279

Cellular Concrete Mattresses for Erosion Control

SECTION 02279

Cellular Concrete Mattresses for Erosion Control

Part 1 General

1.01 Scope of Work

The Contractor shall furnish all labor, materials, equipment, and incidentals required and perform all operations in connection with the installation of cellular concrete erosion control mats in accordance with the lines, grades, design, and dimensions shown on the Drawings and as specified herein.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1. ASTM D6884, "Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems"
2. ASTM D7277, "Standard Test Method for Performance Testing of Articulating Concrete Block (ACB) Revetment Systems for Hydraulic Stability in Open Channel Flow"
3. ASTM D7276, "Standard Guide for Analysis and Interpretation of Test Data for Articulating Concrete Block (ACB) Revetment Systems"
4. U.S. Federal Highway Administration (FHWA) and U.S. Bureau of Reclamation (USBR) Report. FHWA-RD-89-199 Hydraulic Stability of Articulated Concrete Block Revetment Systems During Over-topping Flow.

1.02 Delivery, Storage, and Handling of Materials

1.02.1 Delivery and Storage

Materials delivered to the site shall be inspected for damage, unloaded, and stored with the minimum of handling. Materials shall be kept free of dirt and debris.

1.02.2 Handling

Materials shall be handled in such a manner as to ensure delivery to the site in sound, undamaged condition. Separation geotextiles that are not to be installed immediately shall be protected from the direct sunlight and in accordance with the applicable portions of the Section 02595 - Geotextiles.

1.03 Submittals

The Contract shall provide shop drawings to the Owner's Engineer for approval.

The Contractor shall submit to the Engineer all manufacturers' hydraulic testing and calculations in support of the proposed cellular concrete mat system and geotextile. All calculations submitted must be consistent with the details found in Part 2 of this specification.

The Contractor shall furnish the manufacturer's certificates of compliance for cellular concrete blocks/mats, revetment cable, and any revetment cable fittings and connectors as specified in this document. The Contractor shall also furnish the manufacturer's specifications, literature, shop drawings for the layout of the mats, and any recommendations, if applicable, that are specifically related to the project.

The tapered ShoreBlock SD is considered a system composed of (bottom to top) a properly compacted subgrade, a minimum of 6 inches of washed VDOT Fine Aggregate A sand, CCM Geotextile, a minimum of 4 inches of VDOT #57 aggregate, Synteen SR18 geogrid or approved equal, then the tapered CCM blocks placed upon the geogrid and filled with VDOT #57 aggregate.

Alternative materials may be considered. Such materials must be pre-approved in writing by the Owner's Engineer prior to bid date. Alternative material packages must be submitted to the Owner's Engineer a minimum of fifteen (15) days prior to bid date. Submittal packages must include, at a minimum, the following:

Full-scale laboratory test results and associated engineering calculations quantifying the hydraulic capacity of the proposed cellular concrete mat system in similar conditions to the specific project. The laboratory testing and calculations must comply with all items found in Part 2 of this specification. Submitted calculations must be PE stamped by a duly licensed engineer in the jurisdiction of the project.

Part 2 Materials

2.01 Cellular Concrete Mattresses

Cellular concrete mattresses (CCMs) shall be SHOREBLOCK® Model SD-475-OCT or approved equal.

2.01.1 General Product Description

All cellular concrete mats shall be prefabricated as an assembly of concrete blocks, with specific hydraulic capacities, laced with revetment cables.

Individual units in the system shall be staggered and interlocked for enhanced stability. The mats shall be constructed of open cell units only as shown on the contract drawings. The open cell units have two (2) vertical openings of rectangular cross section with sufficient wall thickness to resist breakage during shipping and installation. The open cell units have an open area of 18-23% as measured from the base of the mat. Parallel strands of cable shall extend through two (2) cable ducts in each block allowing for longitudinal binding of the units within the mat and subsequent ability of the blocks to move freely along the cable. Each row of units shall be laterally offset by one-half of a block width from the adjacent row so that any given block is cabled to four other blocks (two in the row above and two in the row below).

Each block shall incorporate interlocking surfaces that minimize lateral displacement of the blocks within the mats when they are lifted by the longitudinal revetment cables. The interlocking surfaces must not protrude beyond the perimeter of the blocks to such an extent that they reduce the flexibility or articulation capability of the cellular mats or become damaged or broken when the mats are lifted during shipment or placement. Once the mats are in place, the interlocking surfaces shall minimize the lateral displacement of the blocks even if the cables should become damaged or removed. The mats must be able to flex a minimum of 18° between any given row or column of blocks in the uplift direction and a minimum of 45° in the downward direction.

The cables inserted into the mats shall form lifting loops at one end of the mat with the corresponding cable ends spliced together to form a lifting loop at the other end of the mat. The cables shall be inserted after sufficient time has been allowed for the concrete to complete the curing process.

The CCMs shall be placed on geogrid as specified herein. Under no circumstances shall the CCM Geotextile or geogrid be affixed (i.e. chemically bonded to the blocks) to the mattress in a manner in which would jeopardize the functionality of the geosynthetics. Specifically, the geosynthetics shall be independent of the block system.

2.01.2 Independent Testing

All CCM systems shall be independently tested by a facility experienced in performing such tests. All testing and the interpretation of the test data shall conform to the following ASTM standards:

1. ASTM D7277 Standard Test Method for Performance Testing of Articulating Concrete Block (ACB) Revetment Systems for Hydraulic Stability in Open Channel Flow
2. ASTM D7276 Standard Guide for Analysis and Interpretation of Test Data for Articulating Concrete Block (ACB) Revetment Systems

In addition to the above guidance standards, the following specific testing, data analysis and FOS computation requirements shall be met:

The design of the cellular concrete mats shall be in accordance with the equations found in "Design Manual for Articulating Concrete Block (ACB) Revetment Systems, Second Edition NCMA 2010"

The analysis shall be performed based upon the stability of the mat due to gravity forces alone, neglecting conservative forces added by cabling, mechanical anchorage, contact with adjacent blocks, or other restraints not attributable to gravity based forces. The analysis must account for a 0.0-inch block projection. Hydraulic jump analysis based on the correlation between energy ratio and Froude ratio shall also be performed and supported by appropriate test results.

Other factors that must be met for the ACB test results include:

1. For design velocities less than 20 feet per second vertical drop of test flume must be a minimum of 10 feet.
2. All ACB's must be tested on a minimum 2H:1V embankment slope.
3. For design velocities greater than 20 feet per second vertical drop of the test flume section must be greater than 20 feet.
4. Hydraulic jump test data provided on a 2:1 slope or on no less of a slope than the project design.
5. Projection height for tapered blocks is set to 0.0".
6. Reported shear values can only be extrapolated with in the same "family" (having identical foot print in terms of both shape and area) and from lighter to heavier blocks.
7. Testing of the ACB system shall have been completed in 2005 or later.

2.01.3 Project Design Parameters

The following are the specific design parameters the CCM system must be designed to for this project:

Property	Value
Velocity	20 ft/sec
Shear	9.3 lb/ft ²
Side Slope	5H:1V
Bed Slope	5.25%

2.01.4 Size of Cellular Concrete Mattresses.

Mat sizes shall be determined during the layout process which is completed once a purchase order for the project has been issued by the Owner or Contractor. Mat size shall not exceed 8' in width or 40' in length unless special provisions are made ahead of time with the design engineer on a specific project. Mat sizes shall be selected to minimize both freight costs and the amount of grout needed for finishing the revetment system.

2.02 CCM Manufacture

All CCMs will be manufactured in accordance with ASTM 6884.

In addition the following specific conditions and properties will be met:

Compressive Strength Net Area Min. p.s.i		Water Absorption Max. lb/ft ³	
Avg. of 3 units	Individual Unit	Avg. of 3 units	Individual Unit
4,000	3,500	10	12

The manufacturer shall meet all requirements pertaining to a concrete unit's durability pertaining to a freeze-thaw environment as specified in ASTM C1262 and as tested fresh water. The test shall be for 100 cycles with less than a 1% mass loss in the blocks submitted for testing.

A certificate of compliance with the test results specified above and in ASTM 6884 completed in the past 30 months shall be submitted from the manufacturing plant to the Contractor.

2.03 Sampling and Testing

The purchaser or their authorized representative shall be accorded proper access to facilities to inspect and sample the units at the place of manufacture from lots ready for delivery. Additional testing, other than that provided by the manufacturer, shall be borne by the purchaser.

2.04 Revetment Cable

Shall be polyester cable as specified in ASTM 6884. Cable size will be determined by block and mat size and shall provide for a 5.0 or greater factor of safety when lifting.

2.04.1 Polyester Revetment Cable

Polyester Revetment Cable shall be constructed of high tenacity, low elongating, and continuous filament polyester fibers. Cable shall consist of a core construction comprised of parallel fibers contained within an outer jacket or cover. The weight of the parallel core shall be between 65 to 70 percent of the total weight of the cable. Additionally, revetment cable shall have the following physical properties:

NOMINAL CABLE DIAMETER (INCH)	APPROXIMATE AVG. STRENGTH (LB.)	WEIGHT/100 FT. (LB.)
1/4	3,700	2.2
5/16	7,000	4.4
3/8	10,000	5.5
1/2	15,000	9.7

2.04.2 Elongation Requirements

Elongation Requirements specified below are based upon stabilized new, dry cable. Stabilization refers to a process in which the cable is cycled fifty (50) times between a load corresponding to 200D2 and a load equal to 10, 20, or 30 percent of the cable's approximate average breaking strength. Relevant elongation values are as shown on the table below. The tolerance of these values is ± 5 percent.

	At % BREAKING STRENGTH		
	10%	20%	30%
Elastic Elongation	0.6	1.4	2.2

2.04.3 Chemical Resistance

Revetment Cable shall exhibit resistance to most concentrated acids, alkalis, and solvents. Cable shall be impervious to rot, mildew and degradation associated with marine organisms. The materials used in the construction of the cable shall not be affected by continuous immersion in fresh or salt water.

2.04.4 Cable and Fittings

Selection of cable and fittings shall be made in a manner that ensures a safe design safety factor for mattresses being lifted from both ends, thereby forming a catenary. Consideration shall be taken for the bending of the cables around hooks or pins during lifting. Revetment cable splicing fittings shall be selected so that the resultant splice shall provide a minimum of 60% of the minimum rated cable strength. Fittings such as sleeves, stops, and washers shall be in accordance with the manufacturer's recommendations unless otherwise shown on the plans.

2.05 Field Installation

Field installation shall be in accordance with ASTM 6884 unless noted below. The section shall consist, from bottom to top, of properly compacted subgrade, minimum 6 inch thickness of sand, CCM Geotextile, a minimum 4 inch thickness of VDOT #57 aggregate, geogrid, and CCM. The open areas of the CCM shall be filled with VDOT #57 aggregate.

Gaps in the revetment system, whether end to end, side to side or around a radius greater than 2 inches shall be filled with 4000 psi non-shrink grout.

2.05.1 System Components

System components shall be as listed below or an equal approved by the design engineer of record. The CCM below has met the hydraulic requirements of this project. It is the contractor's responsibility to select a manufacturer to meet the physical CCM requirements (i.e., compression, absorption, freeze thaw, etc.) as stated in this specification.

Component	Product
CCM	Shoreblock SD 475 OCT
Cable	Polyester
Fittings	Aluminum
Sand	Washed VDOT Fine Aggregate A
Geotextile	CCM Geotextile
Aggregate	VDOT No. 57
Geogrid	Synteen SR18

2.06 Consultation

The manufacturer of the cellular concrete blocks/mats shall provide design and construction advice during the design and initial installation phases of the project when required.

2.07 Geotextile

The CQA consultant shall sample the subgrade soils for the Owner's Engineer to verify the suitability of the selected CCM Geotextile. The Contractor shall schedule the work to allow for the subgrade testing and verification of the CCM Geotextile prior to purchasing the CCM Geotextile.

Table 2.07
Minimum Physical Requirements for CCM Geotextile

Property	Test Method	Criteria
Grab Tensile Strength	ASTM D 4632	315 lbs.
Grab Elongation	ASTM D 4632	50 percent
CBR Puncture Resistance	ASTM D6241	620 lb
Tear Strength	ASTM D 4533	115 lbs
Apparent Opening Size (Acceptable range)	ASTM D 4751	No. 25 to No. 35 sieve 0.710 mm to 0.500 mm
Permittivity	ASTM D4491	18 gpm/ft ²
UV Stability (percent strength retained at 500 hours)	ASTM D 4355	50 (minimum)

2.08 Geogrid

Geogrid shall be Synteen SR18 or Owner's Engineer approved equal.

Part 3 Execution

3.01 Foundation Preparation

3.01.1 Excavation and Preparation

Excavation and Preparation for anchor trenches, side trenches, and toe trenches or aprons shall be done in accordance to the lines, grades, and dimensions shown on the drawings.

3.01.2 Subgrade and Sand Preparation

Subgrade preparation, including existing subgrade and sand layer, shall be in accordance with ASTM D6884. Subgrade shall be compacted, shaped, and uniformly graded to facilitate intimate contact between the CCM system and the subgrade Soil. Prior to placement, VDOT Fine Aggregate A sand shall be washed to remove fines (material passing the No. 200 sieve) to less than 5 percent.

Voids, pits, or depressions shall be scarified and brought to grade by backfilling.

3.01.3 Placement of CCM Geotextile

CCM Geotextile shall be placed in accordance with ASTM D6884. The geotextile shall be placed in intimate contact with the sand and free from folds or wrinkles. The geotextile shall be placed so that upstream strips overlap downstream strips and upslope strips overlap downslope strips. Longitudinal and transverse joints shall be overlapped at least 12 inches and sewn.

3.01.4 Inspection and Approval.

Immediately prior to placing the sand, CCM Geotextile, aggregate, geogrid, and CCM, the prepared area shall be inspected by the owner's representative and approval obtained before any sand, CCM Geotextile or CCM are placed thereon and prior to purchase of the CCM Geotextile, geogrid, and sand material.

3.02 Installation of Cellular Concrete Mattresses

3.02.1 Placement of CCM

CCM shall be placed in accordance with ASTM D6884 except that vertical projections shall not exceed that specified in Section 3.02.2 herein. In areas of curvature or grade change, alignment of an individual block with adjacent blocks shall be such that intimate contact between the geogrid and No. 57 aggregate and between the CCM Geotextile and underlying sand is maintained. CCM placement shall preferably begin at the upstream section and proceed downstream. Block placement shall not bring block-to-block interconnections in tension.

3.02.2 Vertical Projections

Tapered blocks and mats to be installed so as to result in no (0.0") vertical upwards projection of any block in relation to an adjacent upstream block. If a vertical projection exists, the mat shall be removed along with the underlying geogrid, the drainage aggregate shall be regraded, and the geogrid and CCM shall be replaced.

3.02.3 Broken or Damaged Blocks

Mats with broken blocks shall not be accepted. Individual blocks which are damaged or cracked such that the weight of the block is reduced to 1/3 or less of the original block's weight shall be grouted to completely fill the block area prior to the placement of any required surface treatment.

3.02.4 Termination Trenches

Termination trenches shall be backfilled with 4000 psi non-shrink grout approved by the Owner's Engineer. Termination trenches shall be backfilled with specified material flush with the top of the finished surface of the blocks.

3.03 Finishing

3.03.1 Inspection and Approval

Immediately prior to the placement of any required surface treatment per Section 3.02.2, the QC Team shall inspect the installed CCM for defects and/or damage.

3.02.2 Surface Treatment

After the CCM installation is complete, the open cell voids or joints between the CCM shall be filled with VDOT #57 aggregate.

-End of Section-

SECTION 02280

Gabions

Section 02280

Gabions

Part 1 General

1.01 Description

- A. Scope:
 - 1. This section covers the general requirements for the construction of drainage and erosion control structures including but not limited to, Gabion Baskets as shown on the Contract Drawings.

1.02 Quality Control

- A. Codes, Standards, and Specifications
 - 1. ASTM A641: Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.
 - 2. ASTM C127: Test Method of Specific Gravity and Absorption of Coarse Aggregate.
 - 3. ASTM D1203: Test Methods for Volatile Loss from Plastics Using Activated Carbon Methods.
 - 4. ASTM D1242-95: Test Methods for Resistance of Plastic Materials to Abrasion.
 - 5. ASTM D1499: Recommended Practice for Operating Light-and Water-Exposure Apparatus (Carbon -Arc Type) for Exposure of Plastics.

1.03 Submittals

- A. The CONTRACTOR shall provide a description of the method of installation of the Gabion Baskets, Reno Mattresses, and stone.
- B. Manufacturer's written installation procedures.
- C. The manufacturer's product data, indicating the basket dimensions, mesh opening sizes, wire sizes and thicknesses of protective coatings shall be submitted to the ENGINEER at least four weeks prior to delivery to the site.
- D. The supplier's certification of gradation shall be submitted to the ENGINEER, at least two weeks prior to the delivery of material to the site. The CONTRACTOR shall submit test reports for soundness, durability, and specific gravity.

Part 2 Products

2.01 Acceptable Manufacturers

- A. Maccaferri Gabions, Inc. of Ramsey, New Jersey
- B. Or Equal

2.02 Gabion Baskets

- A. Baskets shall be manufactured in such a manner that their sides, ends, lid, and diaphragms can be assembled to form rectangular units of the specified dimensions. The front, base, back, and lid shall be woven into a single unit. The ends and diaphragms shall be factory connected to the base.

- B. All perimeter edges of the mesh shall be securely selvaged so that the joints obtained have at least the same strength as the wire mesh itself.
- C. The horizontal width of individual Gabion Baskets and Reno Mattress shall not be less than 36 inches except as noted on the Drawings. Where the mattress length exceeds 1-1/2 times its horizontal width, the mattress shall be divided into cells by diaphragms of the same mesh and gauge as a unit body.
- D. The basket structure shall be a hexagonal shaped mesh pattern that under stress will deform but not break. The mesh openings for the Gabion Basket shall measure approximately 3-1/4 inches by 4-1/2 inches, uniform in size. All mesh joints shall be flexible and double twisted to prevent unraveling.
- E. The mesh for the Gabion Baskets shall be galvanized steel wire, having a minimum amount of zinc coating of 0.80 oz/sf of wire and additionally coated with a minimum of 0.020 inch nominal thickness of gray PVC, which shall be suitable to resist destructive effects of immersion in acidic, salt or polluted water, exposure to ultraviolet light and abrasion, and retain these characteristics under test conditions in accordance with ASTM B117, D1499, and D1203.

2.03 Mesh Wire

- A. The nominal diameter of the basket mesh wire shall not be less than 0.1063 inches (U.S. Gauge No. 12) for the Gabion Baskets after zinc coating, and have an overall nominal diameter (core wire plus PVC coating) of not less than 0.1463 inches for the Gabion Baskets.

2.04 Selvedge Wire

- A. The nominal diameter of the selvedge wire (perimeter wire), running through all the edges, shall not be less than 0.1339 inches (U.S. Gauge NO. 10) for the Gabion Baskets after zinc coating and have an overall nominal diameter (core wire plus PVC coating) of not less than 0.1739 inches for the Gabion Baskets.

2.05 Lacing Wire

- A. The nominal diameter of the wire, for assembling and lacing, shall not be less than 0.0866 inches (U.S. Gauge No. 13) for the Gabion Baskets after zinc coating and have an overall nominal diameter (core wire plus PVC coating) of 0.1266 inches for the Gabion Baskets.

2.06 Fill Stone

- A. See Section 02271 for fill stone requirements.

Part 3 Execution

3.01 Product Delivery, Storage, and Handling

- A. No material shall be delivered to the site prior to approval by the ENGINEER.
- B. Inspect materials delivered to Site for damage. Remove all damaged or flawed material from the Site.
- C. Do not store material directly on the ground. Arrange with the ENGINEER for adequate storage.
- D. Carry bundles to work place; dragging of baskets or bundles will not be permitted.

3.02 Subgrade Preparation

- A. The subgrade shall be graded as smooth as possible, clear of sharp objects, boulders, or stumps. Soft or unstable areas shall be repaired and compacted to the required subgrade level at no additional cost. The Separation geotextile as specified in Section 02595 shall be placed on the prepared subgrade before placing the Gabion Baskets.

3.03 Assembling

- A. Gabion and Reno Mattresses shall be assembled in strict accordance with the manufacturer's written instructions prior to placement at the proposed locations.
- B. Single baskets units shall be removed from the bundle, unfolded on a hard flat ground, and all kinks and bends flattened.
- C. The baskets units shall then be assembled individually, by erecting the sides, front, and back panels to a right angle by stepping on the base along the crease. Fold up the end, and diaphragm(s) and fasten them to the front and back panels, ensuring that all creases are in the correct position and the tops of all sides level.
- D. The four corners of the baskets unit shall be laced first, followed by the edges of internal diaphragm(s) to the sides.
- E. The lacing procedure shall consist of cutting a length of lacing wire approximately 1-1/2 times the distance to be laced but not to exceed 5 feet. Secure the wire terminal at the corner by looping and twisting, then proceed to lace with alternating single and double loops at approximately five-inch intervals. Securely fasten the other lacing wire terminal.

3.04 Installation

- A. Placing:
 - 1. After assembly, place the assembled basket units in their proper location as shown on the Drawings. For structural integrity, lace all adjoining empty baskets along the perimeter of all contact surfaces.
 - 2. Once the basket units are laced together, they shall be stretched to effective alignment without deformation. This operation shall be carried out after several empty mattress units have been positioned. The first basket in the line shall be partially filled to provide the necessary anchorage. Any stretching shall be carried out using a fence stretcher or other means of at least one ton capacity.
- B. Filling:
 - 1. Gabion Baskets units shall be filled with the specified stone.
 - 2. Exercise care when placing fill material to assure that the sheathing on PVC coated baskets will not be broken or damaged.
 - 3. Place stone in three-inch thick lifts. Place two connecting wires between each lift along all exposed faces of the baskets. Loop all connecting wires around two mesh openings and securely twist the wire terminals to prevent their loosening.
 - 4. Fill the cells in any row in stages so that local deformation may be avoided. At no time shall any cell be filled to a depth exceeding its specified depth.
 - 5. Along all exposed basket faces, carefully place and pack by hand the outer layer of stone in order to provide proper alignment and a neat, compact, square appearance.

6. Baskets shall be well packed and filled without undue bulging, and provided with secure lacing.

C. Closing:

1. The lids shall be stretched tight over the filling, using crow bars or lid closing tools, until the lid meets the perimeter edges of the front and end panels.
2. The lid shall then be tightly laced along the edges, ends and diaphragm(s) in the same manner as described above for assembling.

D. Cutting and Folding Mesh:

1. Where shown or as required, the CONTRACTOR shall cut the basket mesh, folded and wired together to suit existing site conditions. The mesh must be cleanly cut and the surplus mesh cut out completely, or folded back and neatly wired to an adjacent mattress face. The cut edges of the mesh shall be securely laced together with lacing wire in the manner described above for assembling.

-End of Section-

SECTION 02590

Geocomposite Drainage Net

Section 02590

Geocomposite Drainage Net

Part 1 General

1.01 Summary

- A. Contractor shall furnish all supervision, labor, products, equipment, and tools, including all necessary and incidental items as detailed or required, to install geocomposite drainage net (GDN) in accordance with the Drawings, Specifications, and project Construction Quality Assurance (CQA) Plan.

1.02 References

- A. ASTM International (ASTM) Standards:
1. D 792, "Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement".
 2. D 1238, "Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer".
 3. D 1505, "Standard Test Method for Density of Plastics by the Density-Gradient Technique".
 4. D1505, "Standard Test Method for Density of Plastics by the Density-Gradient Technique".
 5. D 1603, "Standard Test Method for Carbon Black in Olefin Plastics".
 6. D 3786, "Test Method for Bursting Strength of Textile Fabrics: Diaphragm Bursting Strength Tester Method".
 7. D4218, "Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique".
 8. D 4355, "Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon-Arc Type Apparatus".
 9. D 4491, "Test Methods for Water Permeability of Geotextiles by Permittivity".
 10. D 4533, "Test Method for Trapezoidal Tearing Strength of Geotextiles".
 11. D 4632, "Test Method for Grab Breaking Load and Elongation of Geotextiles".
 12. D 4716, "Test Method for Determining the (In-Plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head".
 13. D 4751, "Standard Test Method for Determining Apparent Opening Size of a Geotextile".
 14. D 4833, "Test Method for Index Puncture Resistance of Geomembranes and Related Products".
 15. D 5199, "Test Method for Measuring Nominal Thickness of Geosynthetics".
 16. D 5261, "Test Method for Measuring Mass per Unit Area of Geotextiles".

17. D 5321, "Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear".
18. D6241, "Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe"
19. D7005, "Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites"

1.03 Definitions

- A. Minimum Average Roll Value (MARV): For geosynthetics, the mean value minus two standard deviations calculated from documented quality control test results for a defined population for one specific test method associated with one specific property.
- B. Maximum Average Roll Value (MaxARV): For geosynthetics, the mean value plus two standard deviations calculated from documented quality control test results for a defined population for one specific test method associated with one specific property.

1.04 Submittals

- A. Contractor shall be responsible for timely submittals to the Owner's Representative and Owner.
- B. The following submittals shall be provided:
 1. The GDN and GDN Manufacturer must be approved by the Owner's Representative and Owner prior to Contract award. Submittals for approval include:
 - a. GDN Manufacturer's specification sheet(s) demonstrating compliance with the requirements of Table 1 of this Section.
 - b. GDN Manufacturer's transmissivity test results. GDN transmissivity test procedures and results shall comply with the requirements of Table 1 of this Section. Include two samples of finished GDN, one-sq. yd. each, for possible transmissivity confirmation testing by the Owner's Representative.
 - c. Written certification that the GDN Manufacturer has produced a minimum of 10,000,000 square feet of GDN that has been installed for hydraulic containment purposes in the last 2 years, including a list of the relevant completed facilities. Each entry in this list should include the name, location, and purpose of the facility; GDN product designation, total square footage, and date of installation. Names of the Owner, Designer, GDN Installer, and the name and telephone number of a contact at the facility who can discuss the project shall be provided upon request.
 - d. A copy of the GDN Manufacturer's manufacturing quality control (MQC) manual. This manual should describe the quality control program(s) for GDN components (geonet, nonwoven geotextile, etc.) and finished GDN, and indicate the properties, test methods, and testing frequencies used for each. GDN Manufacturer shall modify the MQC manual to comply with the requirements of these Specifications, with any variations, deviations, or exceptions clearly noted in an attached letter.
 2. Manufacturer's data shall be provided that shows that the GDN will meet the interface shear strength requirements of Table 2 of this Section under

manufacturer's test conditions (site-specific testing shall be performed by the Owner's Representative). Submittals for approval include:

- a. Previous interface shear strength test results for GDN against geomembrane. Conformance test procedures for this interface are outlined in Table 2 of this Section.
 - b. GDN shall only be approved for use with the conformance tested geomembrane. Changes in geomembrane product will require retesting and re-approval of the GDN at no cost to Owner.
3. The GDN Installer must be approved by the Owner's Representative and Owner prior to Contract award. Submittals for approval include:
- a. Written certification that the GDN Installer has installed a minimum of 2,000,000 square feet of GDN for hydraulic containment purposes in the last 2 years, including a list of the relevant completed facilities. Each entry in this list should include the name, location, and purpose of the facility; GDN product designation, total square footage, and date of installation; names of the Owner, Designer, Primary Contractor, and CQA Consultant; and the name and telephone number of a contact at the facility who can discuss the project.
 - b. A copy of the GDN Installer's CQA manual. This manual should describe the quality control program(s) for handling, deploying, anchoring, seaming, and repairing GDN. GDN Installer shall modify the CQA manual to comply with the requirements of these Specifications and the project CQA Plan, with any variations, deviations, or exceptions clearly noted in an attached letter.

C. The following submittals shall be provided after award of Contract:

1. GDN Manufacturer:
 - a. Prior to or coincident with shipment of GDN to the project site, submit written certification and supporting test data documenting that all GDN components and finished GDN shipped to the project site comply with the requirements of Part 2.03 of this Section. This shall include:
 - 1) High density polyethylene (HDPE) geonet and nonwoven polypropylene (PP) geotextile resins (Part 2.03.C of this Section). Certifications shall state the producers, product designations, lot or batch numbers, and production dates of all resins used in the manufacture of GDN components shipped to the project site and shall include copies of all quality control certificates issued by the resin producer.
 - 2) HDPE geonet and nonwoven PP geotextile formulations (Part 2.02B of this Section). Certifications shall state that all formulations used to produce GDN components shipped to the project site comply with the requirements of Part 2.02.B of this Section.
 - 3) Finished HDPE geonet and nonwoven PP geotextiles (Part 2.03 of this Section). Certifications shall include copies of all quality control certificates issued by the Geonet and Geotextile

Manufacturers. Include two samples of finished geonet and finished geotextile, one square yard each, for the project records of the Owner's Representative and CQA Consultant. Each sample shall be labeled with the manufacturer's name, product designation, lot number, roll number, and date of sampling.

- 4) Finished GDN shipped to the project site (Part 2.06.F of this Section). Certifications shall include GDN Quality Control Certificates that have been reviewed and signed by a responsible representative of the GDN Manufacturer.

2. GDN Installer:

- a. Four weeks prior to shipment of GDN to the project site, submit six full sets of field installation drawings for approval to the Owner's Representative. Installation drawings shall show the proposed length, width, and position of all GDN panels and the location of all field seams. GDN panels shall have a distinct identification system. Installation drawings shall also show complete details for field seaming and repairs, anchoring GDN at the perimeter of the installation area, and attachments to structures and other penetrations, as required.
- b. Within 4 weeks after completion of GDN installation, submit a written report containing the following:
 - 1) Written certification stating that the GDN has been installed in accordance with the Contract Drawings, Specifications, and project CQA Plan.
 - 2) Product and installation warranties as required by Part 3.08 of this Section.
 - 3) Copies of daily field records.
 - 4) As-built drawings depicting actual GDN panel placement and all associated details. As-built GDN plans ("panel diagrams") shall be prepared at a reasonable engineering scale using Contractor's surveyed edge of GDN limits (perimeter cap termination areas, runouts, etc.), and shall accurately depict panel orientations and dimensions..

1.05 Construction Quality Assurance

- A. GDN CQA will be performed by the GDN Installer and the Owner's Representative in accordance with the specifications and the project CQA manual.

Part 2 Products

2.01 Geonet

- A. The physical, mechanical, and chemical properties of the geonet shall comply with the requirements of Table 1 of this Section.
- B. Geonet formulation shall consist of at least 97 percent (by weight) polyethylene resin, 2 percent to 3 percent (by weight) of carbon black [added for ultraviolet (UV) radiation resistance], and a maximum of one percent (by weight) of other additives. No plasticizers,

fillers, extenders, post-consumer resin (PCR), or other materials shall be mixed into the formulation. Regrind, rework, or trim materials may be added to the formulation if they are produced by the Geonet Manufacturer and are of the same formulation as the geonet being produced. Regrind, rework, and trim materials shall not exceed 10 percent (by weight) of the geonet formulation.

- C. Polyethylene resin used in the manufacture of geonet is to be made from virgin, uncontaminated ingredients and shall be designed and manufactured specifically for producing geonet. Incoming resin shall be sampled and tested in accordance with the Geonet Manufacturer's MQC program. Testing frequencies, test procedures, and resin properties shall comply with the requirements of Table 1 of this Section. Results from the resin sampling and testing program are to be submitted to the Owner's Representative in accordance with Part 1.04.C.1.a.1 of this Section.
- D. Geonet shall be sampled and tested, prior to incorporation into finished GDN, in accordance with the GDN Manufacturer's approved MQC manual. Testing frequencies, test procedures, and HDPE geonet properties shall comply with the requirements of Table 1 of this Section. Results from the geonet sampling and testing program are to be submitted to the Owner's Representative in accordance with Part 1.04.C.1.a.3 of this Section.

2.02 Geotextile

- A. Geotextiles used in the manufacture of GDN shall be nonwoven needle-punched PP. The physical, mechanical, and chemical properties of the geotextiles shall comply with the requirements of Tables 1 or 3 of this Section, as appropriate. During production, geotextile shall be continuously inspected for the presence of broken needles, which shall be removed from the finished product.
- B. Geotextile formulation shall consist of at least 95 percent (by weight) PP resin, one percent to 3 percent (by weight) of carbon black (added for UV radiation resistance), and a maximum of 2 percent (by weight) of other additives. No plasticizers, fillers, extenders, PCR, or other materials shall be mixed into the formulation. Rework or trim materials may be added to the formulation if they are produced by the Geotextile Manufacturer and are of the same formulation as the geotextile being produced. Rework and trim materials shall not exceed 10 percent (by weight) of the geotextile formulation.
- C. PP resin used in the manufacture of nonwoven geotextile is to be made from virgin, uncontaminated ingredients and shall be designed and manufactured specifically for producing geotextile. Incoming resin shall be sampled and tested in accordance with the Geotextile Manufacturer's MQC program. Testing frequencies, test procedures, and resin properties shall comply with the requirements of Tables 1 or 3 of this Section, as appropriate. Results from the resin sampling and testing program are to be submitted to the Owner's Representative in accordance with Part 1.04.C of this Section.
- D. Geotextile components of the GDN shall be sampled and tested, prior to incorporation into finished GDN, in accordance with the GDN Manufacturer's approved MQC manual. Testing frequencies, test procedures, and PP nonwoven geotextile properties shall comply with the requirements of Tables 1 or 3 of this Section, as appropriate. Results from the geotextile sampling and testing program are to be submitted to the Owner's Representative in accordance with Part 1.04.C of this Section.

2.03 Geocomposite Drainage Net

- A. The GDN and GDN Manufacturer must be approved by the Owner's Representative and Owner prior to Contract award, as required by Part 1.04.B. of this Section.

- B. GDN shall consist of a HDPE geonet with nonwoven geotextiles thermally-bonded to its upper and lower surfaces. The physical, mechanical, and chemical properties of the GDN shall comply with the requirements of Tables 1 and 2 of this Section.
- C. Geonet used in the manufacture of GDN shall be in accordance with the requirements of Part 2.01 of this Section.
- D. Geotextile used in the manufacture of GDN shall be in accordance with the requirements of Parts 2.02A and 2.02B of this Section.
- E. Bonding of the nonwoven geotextiles to the geonet shall be completed in a uniform manner using thermal bonding techniques. Adhesive bonding is not acceptable. Minimum ply adhesion of the thermally bonded surfaces shall be as required in Table 1 of this Section. GDN shall be produced with unbonded panel edges to facilitate field seaming. Unbonded panel edges are to have a minimum width of 3 inches and maximum width of 6 inches. Nonwoven geotextile shall extend a minimum of 3 inches beyond the edges of the geonet on both sides of the GDN.
- F. During production, finished GDN shall be sampled and tested in accordance with the GDN Manufacturer's approved MQC manual. Testing frequencies, test procedures, and finished GDN properties shall comply with the requirements of Table 1 of this Section. Results from the finished GDN sampling and testing program, in the form of Quality Control Certificates, are to be submitted to the Owner's Representative for approval.
- G. GDN shall be produced free of holes, tears, overheated areas, unbonded areas (except for panel edges), contamination by foreign matter, dimensional abnormalities, or other defects. The Owner's Representative may reject all or portions of units (rolls) of GDN shipped to the project site if significant production flaws are observed.
- H. GDN shall be manufactured as a continuous panel having a nominal width of 14 feet and minimum length of 200 feet in order to reduce the amount of field seaming required during installation. Rolls of GDN having lengths shorter than 200 feet may be shipped to the project site if the number of such rolls is approved by the Owner's Representative prior to shipment.
- I. GDN shall be rolled onto hollow cores having a minimum inside diameter of 4 inches to allow the use of a stinger or spreader bar assembly for handling and deployment. Cores shall be of stable construction such that they support the roll without excessively deflecting, buckling, or otherwise failing during handling, transportation, and storage. Each roll of GDN shall be protected by wrapping it in packaging that is waterproof, resistant to photodegradation by UV light, and completely covers all exposed GDN surfaces and edges.
- J. Each GDN roll shall be labeled to identify the GDN Manufacturer, product designation, manufacturer's lot number, manufacturer's roll number, and the length, width, and weight of each roll. Roll identification numbers shall conform to the numbering system established on the GDN Manufacturer's Quality Control Certificates. Labels shall be weather proof, legible, and located so that each roll of GDN can be identified by examining the outside of the roll or the core ends.
- K. At the option of the Owner, the Owner's Representative may inspect the GDN manufacturing process on a full-time basis. This inspection program would include conformance sampling as required. If requested, GDN Manufacturer shall submit a production schedule to the Owner and cooperate with the Owner's Representative during plant inspection.

- L. All GDN components and finished GDN properties, including testing frequencies and test procedures used, shall meet the requirements of this Section. No GDN shall be installed until the Owner's Representative has reviewed all certifications and supporting test data and determined that the GDN delivered to the project site is acceptable for use. Manufacturing records, including test data, shall be maintained by the GDN Manufacturer for 2 years after acceptance of the GDN, and shall be made available upon request.

2.04 Plastic Ties

- A. Plastic ties shall be used to join and make repairs to GDN panels in the field. Ties shall be colored white or yellow to facilitate CQA inspection. Metallic ties or fasteners are not acceptable.

Part 3 Execution

3.01 Pre-Installation Meeting

- A. Prior to scheduled GDN installation, the Owner, Owner's Representative, CQA Consultant, Contractor, and GDN Installer shall attend a pre-installation meeting at the project site.
- B. GDN Installer shall be represented by both the project field superintendent and the project manager.
- C. At the pre-installation meeting, site safety and rules of operation, scheduling, methods of installation, and CQA and quality assurance shall be discussed. The GDN Installer, Owner's Representative, and CQA Consultant shall at this time agree to the required GDN placement, seaming, and repair procedures for the project.

3.02 Shipping, Handling, and Storage

- A. Contractor is responsible for proper shipping, unloading, and storage of the GDN. GDN damaged during shipping, unloading, or storage shall be repaired or replaced at no cost to Owner.
- B. GDN rolls shall be packaged and shipped so that no damage is caused during delivery to the project site. GDN shipping shall be by open or enclosed trailers loaded in such a manner that rolls can be readily unloaded at the project site using slings, a stinger, or a spreader bar assembly. GDN rolls shipped by open trailer shall be protected with a sacrificial or temporary cover during shipment.
- C. During unloading at the project site, Contractor shall conduct a surface inspection of all GDN rolls for defects and damage, including damage to the original protective packaging. Contractor shall immediately notify CQA Consultant and Owner of any defects or damage observed.
- D. Extreme care shall be taken by all personnel while unloading and handling GDN. Equipment used to unload and handle GDN shall have sufficient capacity to manage the roll weight without damaging the GDN. GDN shall only be unloaded and handled using slings, a stinger, or a spreader bar assembly recommended by the GDN Manufacturer or accepted by the CQA Consultant. Pushing, sliding, or dragging of GDN rolls is not permitted. CQA Consultant shall have the option of inspecting all GDN panels, prior to final placement, to verify that all defects or damage are identified for repair.
- E. GDN shall be stored at the project site in an area(s) designated by the Owner and accepted by the CQA Consultant. Contractor shall grade the storage area so that it is

reasonably level and well-drained, and shall prepare the ground surface so that it is firm, smooth, and free of stones, sticks, or other materials that may damage the GDN.

- F. GDN rolls shall be stored off the ground and continuously supported along their length. Stacking of GDN rolls for storage is allowed but should not be so high that crushing of cores or flattening of rolls occurs. In general, the maximum stacking limit is five rolls high. A suitable means of securing the rolls shall be used so that shifting or other adverse movement does not occur.
- G. During storage, GDN shall be protected from moisture, direct sunlight, mud, and excessive dust by covering the rolls with a plastic sheet or waterproof tarpaulin. Roll labels shall remain intact and legible. Any roll of GDN that has no label or where the label is damaged or otherwise illegible may be rejected by the CQA Consultant. GDN rolls shall be kept in their original protective packaging until immediately before they are to be deployed.

3.03 Quality Assurance Conformance Testing

- A. Quality assurance conformance testing of the GDN shall be performed by the CQA Consultant and paid for by the Owner. Conformance sampling and testing shall be completed in accordance with the project CQA Plan, with at least one sample per production lot as directed by the Owner's Representative. Owner has the option to increase the frequency of conformance testing or to sample and test any questionable roll or lot.
- B. Conformance testing of the GDN shall include, but not be limited to, the following properties:
 - 1. Transmissivity, ASTM D 4716
 - 2. Ply Adhesion, ASTM D7005
 - 3. Interface Shear Strength, ASTM D 5321
- C. Engineer may revise the test methods used for determination of conformance properties to allow for use of new or revised methods.
- D. All GDN conformance test results shall comply with the requirements of Tables 1 and 2 of this Section prior to installation. Any GDN that does not conform to these requirements shall be retested or rejected in accordance with the CQA Plan.
- E. GDN that is rejected shall be removed from the project site and replaced at no cost to Owner. Sampling and conformance testing of GDN supplied as replacement for rejected material shall be performed by the CQA Consultant at Contractor's cost.

3.04 Deployment and Placement

- A. GDN installer shall sign a letter accepting the condition of the geomembrane.
- B. GDN shall be deployed and placed in general accordance with the GDN Installer's approved field installation drawings. Depending on field conditions, it may be necessary to alter the GDN panel arrangement from that shown on the approved field installation drawings. These alterations shall be approved by the CQA Consultant prior to GDN deployment.
- C. The Owner's Representative and Owner, in conjunction with the GDN Installer and Contractor, shall establish site-specific limits of weather conditions, including, but not limited to, precipitation and wind speed and direction, within which GDN panel placement can be conducted. In the absence of site-specific criteria, the following limitations shall apply:

1. No placement shall be conducted in the presence of precipitation, such as rain, snow, or sleet.
 2. No placement shall be conducted in the presence of winds in excess of 20 miles per hour or when dirt or debris is blown into working areas.
- D. GDN Installer shall maintain a daily field record of actual placement of each GDN panel, noting subgrade conditions, weather, panel numbers placed, and seaming methods. A copy of each day's field record shall be furnished to the CQA Consultant no later than the following work day.
- E. GDN shall only be placed on geomembrane that has been installed in accordance with the Drawings and Specifications, and has been accepted in writing by the Contractor, GDN Installer, and CQA Consultant. Once geomembrane has been accepted by the CQA Consultant, any additional surface preparation that the Contractor or GDN Installer feels necessary to meet the requirements of the Specifications shall be the responsibility of the Contractor. Geomembrane should have all folds, wrinkles, and other undulations removed and its surface shall be free of rocks, dirt, tools, or other debris before placing GDN. Areas the GDN Installer believes exhibit deficient subgrade conditions shall be reported to the CQA Consultant and Owner for repair.
- F. GDN Installer shall coordinate placement of the GDN with placement of the covering material. All GDN panels shall be appropriately covered within 2 weeks after they are placed to prevent deterioration of the upper geotextile. Any GDN that deteriorates or is otherwise damaged prior to placement of covering material shall be removed and replaced by the GDN Installer, as directed by the CQA Consultant, at no cost to Owner.
- G. It is imperative to keep surface water runoff containing sediment or other debris from contacting the GDN at all times during installation. GDN Installer's panel placement techniques and covering schedule shall minimize or eliminate the potential for accumulation of sediment or other debris on the GDN. GDN Installer shall remove accumulated sediment or debris by sweeping, hosing, or other methods acceptable to the CQA Consultant, prior to covering the GDN. Any GDN that cannot be adequately cleaned shall be removed and replaced by the GDN Installer, as directed by the CQA Consultant, at no cost to Owner.
- H. Extreme care shall be taken by all personnel while handling, unwrapping, deploying, and placing GDN. Equipment and tools used shall not stretch, tear, crimp, fold, or otherwise damage the GDN, and shall not cause damage to the underlying geomembrane. Equipment shall have sufficient capacity to manage the roll weight without damaging the GDN. GDN shall only be handled and deployed using a stinger or spreader bar assembly recommended by the GDN Manufacturer or acceptable to the CQA Consultant. Pushing, sliding, or dragging of GDN rolls is not permitted.
- I. Under no circumstances shall any construction or vehicular traffic be allowed to drive over exposed GDN. GDN showing evidence of trafficking shall be inspected by the GDN Installer, Contractor, and CQA Consultant to evaluate damage, if any. At the direction of the CQA Consultant, any damaged GDN shall be repaired or replaced at no cost to Owner. CQA Consultant may allow limited use of four-wheeled all-terrain vehicles or other low ground pressure equipment (having 6 pounds per square inch or less contact pressure) by the GDN Installer during installation, but use shall be prohibited if excessive trafficking or any GDN damage is observed.

- J. GDN rolls shall be transported from the storage area to the working area in their original protective packaging. After packaging is carefully removed, GDN shall be unrolled and placed in such a manner as to minimize dragging of panels into position ("spotting"). The GDN shall not be dragged across textured geomembrane. A temporary smooth geosynthetic subgrade covering ("slip sheet") shall be used to protect the bottom surface of the GDN from damage, as directed by the CQA Consultant.
- K. GDN Installer shall immediately provide temporary anchorage of the GDN to prevent wind uplift, bridging (refer to Part 3.04.L of this Section for bridging requirements), and panel movement during placement of covering materials. No permanent bonding of GDN to geomembrane shall be permitted. Temporary anchorage methods shall be approved by the Owner's Representative and CQA Consultant. If bags are used for temporary anchorage, they shall be filled with aggregate, sand, or soil that has been approved for use by the CQA Consultant. Any GDN exhibiting damage due to insufficient or improper temporary anchorage shall be repaired or replaced, as directed by the CQA Consultant, at no cost to Owner.
- L. GDN shall be installed so that is in continuous contact with the underlying geomembrane surface, without being tensioned, and with no wrinkles or folds. Bridging at the toe of slopes or within pipe trenches shall not be permitted. If bridging is observed, GDN Installer shall repair affected areas, as directed by the CQA Consultant, at no cost to Owner.
- M. GDN panel seams (edges) shall be oriented in a direction parallel to the line of maximum subgrade slope (i.e., down, not across the slope) and shall be placed in a manner that minimizes the number and length of field seams. In corners and odd-shaped geometric locations where panel seams are staggered or butted, an extra layer of GDN shall be installed from the crest to the toe of the slope.
- N. All GDN panel seams parallel to the toe of a slope ("longitudinal seams") shall be located at least 5 feet from the toe of the slope, except where explicitly approved by the CQA Consultant. Longitudinal seams are permitted on sideslopes, but must be staggered in a manner approved by the Owner's Representative and CQA Consultant.
- O. Contractor shall be responsible for excavation, maintenance, and backfilling of the perimeter liner termination area in accordance with the perimeter liner termination area requirements outlined in Section 02597 – Linear Low Density Polyethylene Geomembrane, of the Specifications. Backfilling of the perimeter liner termination area shall commence only after the GDN has been approved by the CQA Consultant. Backfilling materials and compaction methods shall be as outlined in Section 02200 – Earthwork of these Specifications.

3.05 Seaming

- A. A combination of lap joints (geonet) and sewing (geotextile) shall be used to join GDN panels in the field. A minimum geonet overlap of 3 inches shall be used for panel edges and a minimum GDN overlap of 24 inches shall be used for panel ends. Overlap areas shall be kept free of rocks, loose soil, or other debris. All GDN panels should be seamed as soon as possible after they are placed and prior to being covered.
- B. Geonet overlaps along panel edges shall be secured using a minimum of one plastic tie per 5 linear feet of seam except in perimeter liner termination areas, where spacing shall be a minimum of one plastic tie per 6 linear inches of seam. Geonet overlaps in corners or other odd-shaped geometric locations where panel seams are staggered or butted shall be secured using a minimum of one plastic tie per 6 linear inches of seam. GDN panel end

seams shall be secured using a minimum of one plastic tie per 6 linear inches of seam, this requirement may be omitted on flat slopes if approved by the Owner's Engineer and Manufacturer. At the panel butt ends, geotextile of the same weight as the top geotextile on the GDN shall be placed over the GDN overlap and heat bonded to the adjoining GDN panels, with a minimum overlap of 12 inches on either side.

- C. GDN panel edge overlap areas shall be left open (i.e., upper geotextiles pulled back) after placing plastic ties to allow the CQA Consultant to verify that the overlap area and tie spacing meet the requirements of this Section. Geotextile overlaps shall not be closed and sewn until verbal acceptance of the geonet seam is given by the CQA Consultant.
- D. Geotextile overlaps on GDN panel edges shall be joined with a flat ("prayer") seam using two rows of Type 401 stitching. All sewn seams shall be continuous and completed using thread made from the same type of polymer as the geotextiles being sewn together. Sewing thread should be a color that contrasts the geotextile color. Thermal seaming methods may be accepted if successfully demonstrated in the field and approved by the Owner's Representative and CQA Consultant. Geotextile overlaps at panel intersections and odd corner seams may be heat bonded at the discretion of the Owner's Representative or CQA Consultant.
- E. Completed GDN seams shall lay flat and be free of any rocks, loose soil, or other debris. Where wrinkles or folds do occur, the material shall be cut, overlapped, and a patch applied in accordance with Part 3.06 of this Section.

3.06 Repairs

- A. During installation, GDN Installer and CQA Consultant shall visually inspect all GDN panels and seams for damage, defects, or non-compliance with the Drawings and Specifications, and shall mark any such areas for repair. GDN Installer shall repair marked areas as soon as possible and prior to covering the GDN.
- B. Acceptable GDN repair methods include:
 - 1. Patching: For repair of surface defects, small tears, punctures, etc. Patches shall have a minimum size of 24 inches by 24 inches and extend at least 12 inches beyond the edge(s) of a defect. Patches shall be secured to original GDN using plastic ties placed at minimum 6-inch spacing around the patch. Geotextile shall be heat bonded over the edges of the patch as described in Part 3.05 of this Section.
- C. If an area to be repaired is more than 50 percent of the width of a GDN panel, the damaged area shall be removed across the entire panel width and the two remaining portions of GDN shall be joined in accordance with Part 3.05 of this Section. Such repair areas shall be explicitly approved by the CQA Consultant prior to making the repair.

3.07 Acceptance and Covering

- A. No GDN shall be covered until it has been accepted by the CQA Consultant in writing.
- B. GDN Installer shall repair any areas identified by the CQA Consultant as not being in accordance with the Drawings and Specifications. Once all repairs are completed and accepted by the CQA Consultant, GDN shall immediately be covered in accordance with the Drawings and Specifications.
- C. All GDN panels shall be covered with cover soils within 2 weeks after they are placed to prevent deterioration of the upper geotextile. Any GDN that deteriorates or is otherwise

damaged prior to placement of covering material shall be removed and replaced by the GDN Installer, as directed by the CQA Consultant, at no cost to Owner.

- D. If textured geomembrane is used below the GDN, a smooth temporary geosynthetic covering ("slip sheet") shall be used to protect the lower surface of the GDN from damage until the geomembrane is in its final position for seaming.

3.08 Warranties

- A. Contractor shall be responsible for obtaining any necessary guarantees or certifications from the GDN Manufacturer and GDN Installer and submitting them to the Owner's Representative and Owner prior to acceptance of installed GDN.
- B. Contractor shall guarantee the integrity, within the realm of limitations of Contractor's responsibility, of the installed GDN for its intended use, from installation defects for a period of 2 years from the date of GDN installation, and from manufacturing defects for a period of 5 years from the date of GDN installation. Such written warranties shall provide for the total and complete repair and/or replacement of any defect or defective areas of GDN upon written notification and demonstration by the Owner of the specific non-conformance of the GDN or installation with the Drawings and Specifications. Such defects or non-conformance shall be repaired and/or replaced expeditiously, at no cost to Owner.

Table 1
Required Properties of GDN^(1, 2)

Property (Units)	MQC Testing Frequency (Minimum)	Test Method ⁽³⁾	Required Value
HDPE Geonet Resin			
Density (g/cc)	1 per Resin Batch	ASTM D 1505 or D 792	0.940 (min)
Melt Flow Index (g/10 mins)	1 per Resin Batch	ASTM D 1238, Condition 190/2.16	1.0 (max)
Finished HDPE Geonet⁽⁴⁾			
Density, (g/cc)	Every 50,000 ft ²	ASTM D 1505 or D 792	0.940 (min ave)
Thickness (mil)	Every 50,000 ft ²	ASTM D 5199	270±15 (range) ⁽⁵⁾
Carbon Black Content (%)	Every 50,000 ft ²	ASTM D 4218	2.0 - 3.0 (range)
Finished Nonwoven PP Geotextile⁽⁴⁾			
Mass per unit Area (oz./yd. ²)	Every 100,000 ft ²	ASTM D 5261	8.0 (MARV)
Grab Tensile Strength (lb)	Every 100,000 ft ²	ASTM D 4632	203 (MARV)
Tear Strength (lb)	Every 100,000 ft ²	ASTM D 4533	79 (MARV)
Puncture Strength (lb)	Every 100,000 ft ²	ASTM D 6241	650 (MARV)
Permittivity (sec ⁻¹)	Every 500,000 ft ²	ASTM D 4491	1.26 (MARV)
Apparent Opening Size (mm)	Every 500,000 ft ²	ASTM D 4751	0.18 (MaxARV)
UV Stability (percent strength retained at 500 hours)	Per Formulation	ASTM D 4355	70 (min)
Finished GDN			
100-hr Transmissivity (m ² /sec)	Every 500,000 ft ²	ASTM D 4716	4.1 x 10 ⁻⁴ (MARV) ⁽⁵⁾
Ply Adhesion (lb/in)	Every 15,000 ft ²	ASTM D7005	1.0 (MARV) ⁽⁶⁾

Notes:

- (1) Table 1 testing to be performed by the manufacturer.
- (2) The required properties specified herein may be revised by the Engineer to reflect new or revised test methods or to conform with improvements to the state-of-the practice.
- (3) Number of specimens per test established in applicable test method unless otherwise noted.
- (4) Perform tests on material before incorporation into finished GDN.
- (5) Perform test using rigid platen for substrate and Protective Cover Soil compacted per Owner's Engineer requirements for the superstratum. Test conditions: Normal stress = 300 pounds per square foot; Hydraulic gradient = 0.25; Seating period = 100 hours.
- (6) Average of five equally spaced tests across the roll width. Lowest individual value = 0.5-pound per inch (lb/in).

Table 2
Interface Shear Strength Requirements for GDN^(1, 2, 3, 4)

Testing Set-Up		
Standard Test	Conditioning and Set-up:	Set up each test to match field placement orientation. Run all tests under wet conditions.
	Procedure A:	GDN against Geomembrane Substrate: Project Textured 40 Mil LLDPE Geomembrane Superstratum: Project GDN Displacement Rate: 0.04-ipm (maximum) Total Displacement: 2.5 inches (minimum)
	Procedure B:	GDN against Site Protective Cover Soil Substrate: Project GDN Superstratum: Site Protective cover soil at 90% Standard Proctor MDD ± 3% OMC Displacement Rate: 0.04-ipm (maximum) Total Displacement: 2.5 inches (minimum)
	Special Instructions:	None.
Normal Load [Pounds per Square Foot (psf)]		Standard Test
		Peak Shear Strength
150		20 Degrees
300		
600		
1000		

Notes:

- (1) Table 2 testing to be performed by the Owner's Representative in accordance with ASTM D 5321 utilizing the test conditions and procedures outlined in Table 2. GDN is not acceptable if geotextile delaminates from the geonet, even if required strengths are attained. Test frequency as per the CQA Plan.
- (2) Test individual interfaces between Steel rasp platens. In lieu of testing individual interfaces, a system test may be performed using configuration that allows failure to occur through the weakest shearing plane. System test configuration, conditions, and procedures must be accepted by the Engineer prior to submitting test results for review and approval.
- (3) Interfaces shall be saturated for a minimum of 24 hours prior to testing.
- (4) Geosynthetics shall be oriented such that the shear force is parallel to the down slope orientation of these components in the field.

-End of Section-

SECTION 02595

Geotextiles

Section 02595 Geotextiles

Part 1 General

1.01 Summary

- A. This section includes the technical requirements for materials and installation of geotextiles.

1.02 References

The following codes and standards are referenced in this section:

- A. ASTM International (ASTM) Standards:
 - 1. D 3786, "Test Method for Bursting Strength of Fabrics: Diaphragm Bursting Strength Tester Method".
 - 2. D 4355, "Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon-Arc Type Apparatus".
 - 3. D 4533, "Test Method for Trapezoidal Tearing Strength of Geotextiles".
 - 4. D 4632, "Test Method for Grab Breaking Load and Elongation of Geotextiles".
 - 5. D 4751, "Test Method for Determining Apparent Opening Size of a Geotextile."
 - 6. D 4833, "Test Method for Index Puncture Resistance of Geomembranes and Related Products".
 - 7. D 5261, "Standard Test Method for Measuring Mass per Unit Area of Geotextiles".
 - 8. D 5321, "Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear".
- B. Geosynthetic Research Institute (GRI):
 - 1. Guide GS11, "Standard Guide for Constructing Test Pads to Assess Protection Materials Intended to Avoid Geomembrane Puncture."

1.03 Definitions

- A. Minimum Average Roll Value (MARV): For geosynthetics, the mean value minus two standard deviations calculated from documented quality control test results for a defined population for one specific test method associated with one specific property.
- B. Maximum Average Roll Value (MaxARV): For geosynthetics, the mean value plus two standard deviations calculated from documented quality control test results for a defined population for one specific test method associated with one specific property.

Part 2 Products

2.01 Geotextile

- A. The geotextiles shall be geotextile made up of polypropylene (PP) filaments. The physical, mechanical, and chemical properties of the geotextile shall comply with the requirements of this Section. During production, geotextile shall be continuously inspected for the presence of broken needles, which shall be removed from the finished product. The use of

woven slit film geotextiles (i.e. geotextiles made from yarns of flat, tape-like character) and heat calendared nonwoven geotextiles will not be allowed.

- B. Geotextile formulations shall consist of at least 95 percent (by weight) PP resin. No plasticizers, fillers, extenders, post-consumer resin, or other materials shall be mixed into the formulation. Rework or trim materials may be added to the formulation if they are produced by the Geotextile Manufacturer and are of the same formulation as the geotextile being produced. Rework and trim materials shall not exceed 10 percent (by weight) of the geotextile formulation.
- C. PP resin used in the manufacture of nonwoven geotextile is to be made from virgin, uncontaminated ingredients and shall be designed and manufactured specifically for producing geotextile. Incoming resin shall be sampled and tested in accordance with the Geotextile Manufacturer's manufacturing quality control program. Testing frequencies, test procedures, and resin properties shall comply with the requirements of this Section. Results from the resin sampling and testing program are to be submitted to the Engineer.
- D. The hybrid monolithic woven-nonwoven needle-punched underdrain geotextile meeting the requirements of Table 4. Qualified materials shall be the top (hybrid) geotextile from CoalDrain 300 mil Geocomposite as manufactured by GSE or equal as approved by the Owner's Representative.
- E. Where applicable, Tables 1a, 2, 3, and 4 property values represent the MARV in the weakest principal directions. Except where noted otherwise, values for AOS represent the minimum values and corresponding 95 percent opening size (O_{95}) represents the MaxARV.

2.02 Material Requirements

Table 1a
Minimum Physical Requirements for Cushion Geotextile⁽¹⁾

Property	Test Method	Criteria
Weight	ASTM D 5261	12 oz./sq. yd. minimum
Grab Tensile Strength	ASTM D 4632	300 pounds (lbs)
Grab Elongation	ASTM D 4632	50 percent
Trapezoid Tear Strength	ASTM D 4533 (in machine and cross-machine directions)	115 lbs
Puncture Strength	ASTM D 6241	800 lbs
UV Stability (percent strength retained at 500 hours)	ASTM D 4355	70 (minimum)
Minimum Interface Shear Strength	ASTM D 5321	See Table 2-2 of the Linear Low Density Polyethylene Specification

Note:

(1) Nonwoven.

Table 1b
Interface Shear Strength Requirements for
Cushion Geotextile ^(1, 2)

Testing Set-Up		
ASTM D5321	Conditioning:	Set up each test to match field placement orientation. Run all tests under wet conditions.
	Procedure A:	Cushion Geotextile against Prepared Subgrade Substrate: Prepared Subgrade Soil Compacted Simulating Field Conditions Superstratum: Project Cushion Geotextile Displacement Rate: 0.04 ipm (maximum) Total Displacement: 2.50 in (minimum)
	Special Instructions:	None.
Strength Requirements		
Normal Stress [Pounds per Square Foot (psf)]		Minimum Peak Shear Strength
150		20 degrees
300		
600		
1000		

Notes:

- (1) Table 1b testing to be provided by the Owner's Representative. Test individual interfaces between Steel rasp platens. In lieu of testing individual interfaces, a system test may be performed using a configuration that allows failure to occur through the weakest shearing plane. System test configuration, conditions, and procedures must be accepted by the Engineer prior to submitting test results for review and approval.
- (2) Test frequency as per CQA Plan.

Table 2
Minimum Physical Requirements for Separation Geotextile ⁽¹⁾

Property	Test Method	Criteria
Weight(Typical)	ASTM D5261	12.0 oz/sy
Grab Tensile Strength	ASTM D 4632	315 lbs.
Grab Elongation	ASTM D 4632	50 percent
CBR Puncture Resistance	ASTM D6241	850 lb
Tear Strength	ASTM D 4533	115 lbs
Permittivity	ASTM D4491	0.9 sec-1
Water Flow	ASTM D4491	70 gpm/ft ²
Apparent Opening Size	ASTM D 4751	0.150 mm (maxARV)
UV Stability (percent strength retained at 500 hours)	ASTM D 4355	50 (minimum)

Note:

⁽¹⁾ Nonwoven.

Table 3
Physical Requirements for Nonwoven Filter Geotextile

Property	Test Method	Criteria
Mass per unit Area (oz./yd. ²)	ASTM D 5261	8.0 (MARV)
Grab Tensile Strength (lb)	ASTM D 4632	205 (MARV)
Tear Strength (lb)	ASTM D 4533	85 (MARV)
Puncture Strength (lb)	ASTM D 6241	535 (MARV)
Permittivity (sec ⁻¹)	ASTM D 4491	1.3 (MARV)
Apparent Opening Size (mm)	ASTM D 4751	0.18 (MaxARV)
UV Stability (percent strength retained at 500 hours)	ASTM D 4355	70 (min)

Table 4
Required Properties of Underdrain Geotextile

Property (Units)	MQC Testing Frequency (Minimum)	Test Method	Required Value
Composite Geotextile⁽²⁾			
Structure	Hybrid Monolithic Woven-Nonwoven Needlepunched		
Mass per unit Area (oz./yd. ²)	Every 100,000 ft ²	ASTM D 5261	14 (MARV)
Grab Tensile Strength (lb)	Every 100,000 ft ²	ASTM D 4632	200 (MARV)
Tear Strength (lb)	Every 100,000 ft ²	ASTM D 4533	85 (MARV)
Puncture Strength (lb)	Every 100,000 ft ²	ASTM D 6241	775 (MARV)
Permittivity (sec ⁻¹)	Every 500,000 ft ²	ASTM D 4491	0.3 (MARV)
Apparent Opening Size (mm)	Every 500,000 ft ²	ASTM D 4751	0.088 (MaxARV)
UV Resistance, % retained	Per Formulation	ASTM D 4355	70 (typical)
Typical Roll Dimensions ⁽³⁾			
Roll Width, ft			15.0
Roll Length, ft			160

Note:

⁽¹⁾ Roll widths and lengths have a tolerance of ±1%.Part 3Execution

3.01 Geotextile Installation

- A. During all periods of shipment and storage, the geotextile shall be protected from direct sunlight, ultraviolet rays, and temperatures greater than 140 degrees Fahrenheit. To the extent possible, the geotextile shall be maintained wrapped in its protective covering. The geotextile shall not be exposed to sunlight, ultraviolet rays until the installation process begins.
- B. Cushion Geotextile shall only be placed on the Prepared Subgrade surface that has been installed in accordance with the Drawings and Specifications, and has been accepted in writing by the Contractor, Geotextile Installer, Geomembrane Installer, and Owner's Representative. Once Prepared Subgrade surface has been accepted by the Owner's Representative, any additional surface preparation that the Contractor, Geotextile Installer, or Geomembrane Installer feels necessary to meet the requirements of the Specifications shall be the responsibility of the Contractor. Cushion geotextile may be omitted if approved in writing by the Owner's Engineer and the subgrade particles protrude less than 3/8 inch. Maximum allowable protrusions beneath specified Cushion Geotextile will be as determined by the Owner's Engineer and may be determined by a test pad in accordance with GRI GS11.
- C. Prepared Subgrade surface shall be free of dirt, tools, or other debris before placing Cushion Geotextile or Geomembrane. Areas the Geotextile Installer or Geomembrane Installer believes exhibit deficient subgrade conditions shall be reported to the Owner's Representative and Owner for repair.

- D. Filter, Underdrain, and Separation Geotextiles shall be placed as indicated on the Drawings.
- E. On slopes, the geotextiles shall be securely anchored and then rolled down the slope in such a manner as to continually keep the geotextile in tension.
- F. In the presence of wind, all geotextiles shall be weighted with sandbags or the equivalent. Sandbags shall be installed during placement and shall remain until replaced with protective cover soils.
- G. Geotextiles shall be kept continually under slight tension to minimize the presence of wrinkles in the geotextile.
- H. Geotextiles shall be cut using an approved geotextile cutter only. If in place, special care shall be taken to protect other materials from damage which could be caused by the cutting of the geotextiles.
- I. The Installer shall take any necessary precautions to prevent damage to the underlying geomembrane during placement of the geotextile.
- J. During placement of geotextiles, care shall be taken not to entrap in the geotextile: stones, excessive dust, or moisture that could damage the underlying geomembrane, or hamper subsequent seaming.
- K. If white-colored geotextile is used, precautions shall be taken against "snow blindness" of personnel.
- L. Horizontal seams shall be minimized as much as practical, except as part of a patch. The Contractor shall pay particular attention at seams so that no material could be inadvertently inserted beneath the geotextiles.
- M. Continuously overlap cushion geotextile panels a minimum of 12 inches at all longitudinal and transverse joints. Continuously overlap nonwoven filter geotextile panels a minimum of 18 inches at all longitudinal and transverse joints. If approved, sewn seams may be used for cushion and nonwoven geotextiles instead of overlapped seams. If sewn, cushion and nonwoven filter geotextiles shall be continuously sewn together with two rows of Type 401 stitching (field-stitch). Geotextiles shall be overlapped at a minimum of 6 inches prior to seaming. Sewing shall be done using thread made from the same type of polymer as the geotextile being sewn together. Sewing thread should be a color that contrasts the geotextile color. Thermal seaming methods may be accepted if successfully demonstrated in the field and approved by the Engineer and Owner's Representative.
- N. Continuously overlap separation geotextile panels beneath riprap a minimum of 24 inches at all longitudinal and transverse joints, and continuously overlap separation geotextile panels beneath other materials a minimum of 18 inches at all longitudinal and transverse joints
- O. Continuously overlap underdrain geotextile panels a minimum of 18 inches across the top of the trench and a minimum of 3 feet for end-to-end panels.
- P. Extreme care shall be taken by all personnel while handling, unwrapping, deploying, and placing geotextile. Equipment and tools used shall not stretch, tear, or otherwise damage the geotextile, and shall not cause damage to the underlying geomembrane. Equipment shall have sufficient capacity to manage the roll weight without damaging the geotextile. Geotextile shall only be handled and deployed using a stinger or spreader bar assembly

recommended by the Geotextile Manufacturer or acceptable to the Owner's Representative. Pushing, sliding, or dragging of geotextile rolls is not permitted.

- Q. Under no circumstances shall any construction or vehicular traffic be allowed to drive over exposed geotextile. Geotextile showing evidence of trafficking shall be inspected by the Geotextile Installer, Contractor, and Owner's Representative to evaluate damage, if any. At the direction of the Owner's Representative, any damaged geotextile shall be repaired or replaced. Owner's representative may allow limited use of four-wheeled all-terrain vehicles or other low ground pressure equipment (having 6 pounds per square inch or less contact pressure) by the Geotextile Installer during installation, but use shall be prohibited if excessive trafficking or any geotextile damage is observed.
- R. Geotextile Installer shall immediately provide temporary anchorage of the geotextile to prevent wind uplift and panel movement during placement of covering materials. No permanent bonding of geotextile to geomembrane shall be permitted. Temporary anchorage methods shall be approved by the Engineer and Owner's Representative. If bags are used for temporary anchorage, they shall be filled with aggregate, soil or fine-grained sand that has been approved for use by the Owner's Representative. Any geotextile exhibiting damage due to insufficient or improper temporary anchorage shall be repaired or replaced, as directed by the Owner's Representative.
- S. Geotextile panel seams (edges) shall be oriented in a direction parallel to the line of maximum subgrade slope (i.e., down, not across the slope) and shall be placed in a manner that minimizes the number and length of field seams.
- T. Where separation geotextile is used in channel linings, all folds and wrinkles should be removed from the geotextile before the channel lining is placed on top of it. Place the geotextile so that there is sufficient overlap to seal the seams for intrusion of water and ensure minimal stretch of the geotextile material. Upstream strips of material must overlap the downstream strips and upslope strips overlap downslope strips.
- U. All geotextile panel seams parallel to the toe of a slope ("longitudinal seams") shall be located at least 5 feet from the toe of the slope, except where explicitly approved by the Owner's Representative. Longitudinal seams are permitted on side slopes, but must be staggered in a manner approved by the Engineer and Owner's Representative.
- V. Underdrain geotextile shall be placed in pond ash, **with the nonwoven side of the hybrid geotextile placed against the ash**. Underdrain geotextile shall be installed at locations necessary for construction dewatering and approved by the Owner's Representative. All placement of Underdrain geotextile and associated aggregate and piping shall be observed by the CQA Consultant. Underdrain geotextile installation shall be approved by the CQA Consultant prior to installation of the associated underdrain aggregate and piping.

3.02 Repairs

- A. During installation, Geotextile Installer and Owner's Representative shall visually inspect all geotextile panels and seams for damage, defects, or non-compliance with the Drawings and Specifications, and shall mark any such areas for repair. Geotextile Installer shall repair marked areas as soon as possible and prior to covering the geotextile with the drainage layer material.
- B. Acceptable geotextile repair methods include:

1. Patching: For repair of surface defects, small tears, punctures, etc. Patches shall have a minimum size of 24 inches by 24 inches and extend at least 12 inches beyond the edge(s) of a defect. Patches shall be secured to original geotextile using adhesive or by hot-air bonding ("leistering") around the patch.
- C. If an area to be repaired is more than 50 percent of the width of a geotextile panel, the damaged area shall be removed across the entire panel width and the two remaining portions of geotextile shall be joined in accordance with this Section. Such repair areas shall be explicitly approved by the Owner's Representative prior to making the repair.

3.03 Final Inspection, Acceptance, and Covering

- A. No geotextile shall be covered until it has been accepted by the Owner's Representative in writing.
- B. Geotextile Installer shall repair any areas identified by the owner's Representative as not being in accordance with the Drawings and Specifications. Once all repairs are completed and accepted by the Owner's Representative, geotextile shall immediately be covered in accordance with the Drawings and Specifications.
- C. All geotextile panels shall be covered within 2 weeks after they are placed to prevent deterioration of the geotextile. Any geotextile that deteriorates or is otherwise damaged prior to placement of covering shall be removed and replaced by the Geotextile Installer, as directed by the Owner's Representative, at no cost to the Owner.

-End of Section-

SECTION 02597

Linear Low Density Polyethylene Geomembrane

Section 02597

Linear Low Density Polyethylene Geomembrane

Part 1 General

1.01 Summary

- A. Contractor shall furnish all supervision, labor, products, equipment, and tools, including all necessary and incidental items as detailed or required, to install geomembrane in accordance with the Drawings, Specifications, and project Construction Quality Assurance (CQA) Plan.

1.02 References

- A. ASTM International (ASTM) Standards:
 - 1. D 792, "Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement".
 - 2. D 1004, "Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting".
 - 3. D 1238, "Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer".
 - 4. D 1505, "Standard Test Method for Density of Plastics by the Density-Gradient Technique".
 - 5. D 1603, "Standard Test Method for Carbon Black in Olefin Plastics".
 - 6. D 3895, "Standard Test Method for Oxidative Induction Time of Polyolefins by Differential Scanning Calorimetry".
 - 7. D 4218, "Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique".
 - 8. D 4833, "Test Method for Index Puncture Resistance of Geomembranes and Related Products".
 - 9. D 5321, "Standard Test Method for Determining the Strength of Soil-Geosynthetic and Geosynthetic Interfaces by Direct Shear".
 - 10. D 5596, "Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics".
 - 11. D 5885, "Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry".
 - 12. D 5994, "Test Method for Measuring the Core Thickness of Textured Geomembranes".
 - 13. D 6392, "Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods".
 - 14. D 6693, "Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes".

15. D 7466, "Standard Test Method for Measuring the Asperity Height of Textured Geomembrane".

B. Geosynthetic Research Institute (GRI) Standards:

1. GRI Test Method GM 17, "Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes".

1.03 Definitions

- A. Formulation: The mixture of a unique combination of ingredients identified by type, properties, and quantity. For LLDPE geomembrane, a formulation is defined as the exact percentages and types of resin(s), additives, and carbon black.

1.04 Submittals

- A. Contractor shall be responsible for timely submittals to the Engineer and Owner.
- B. The following submittals shall be provided:
1. The geomembrane and Geomembrane Manufacturer must be approved by the Engineer and Owner prior to Contract award. Submittals for approval include:
 - a. Geomembrane Manufacturer's specification sheet(s) demonstrating compliance with the requirements of Table 1 of this Section.
 - b. Written certification that the Geomembrane Manufacturer has produced a minimum of 10,000,000 square feet of LLDPE geomembrane that has been installed for hydraulic containment purposes in the last 2 years, including a list of the relevant completed facilities. Each entry in this list should include the name, location, and purpose of the facility; geomembrane thickness, total square footage, and date of installation. Names of the Owner, Designer, Fabricator (if any), and Geomembrane Installer; and the name and telephone number of a contact at the facility who can discuss the project shall be provided upon request.
 - c. A copy of the Geomembrane Manufacturer's manufacturing quality control (MQC) manual. This manual should describe the quality control program(s) for formulation ingredients (raw materials), finished geomembrane sheet, and extrudate rod, and indicate the properties, test methods, and testing frequencies used for each. Geomembrane Manufacturer shall modify the MQC manual to comply with the requirements of these Specifications, with any variations, deviations, or exceptions clearly noted in an attached letter.
 2. The geomembrane shall meet the interface shear strength requirements of Table 2 of this Section. Interface shear strength testing to verify compliance with the requirements of Table 2 shall be performed by the Owner's Representative as noted in Part 3.03 of this section. However, the Geomembrane Manufacturer shall review the interface shear strength requirements and test procedures outlined in Table 2 to avoid proposing the use of a geomembrane product(s) that will not meet these requirements. The interfaces that exist for this project include:
 - a. Geomembrane against Prepared Subgrade.
 - b. Geomembrane against cushion geotextile.
 - c. Geocomposite drainage net (GDN).

3. The Geomembrane Installer must be approved by the Engineer and Owner prior to Contract award. Submittals for approval include:

- a. Written certification that the Geomembrane Installer has installed a minimum of 10,000,000 square feet of LLDPE and/or high density polyethylene (HDPE) geomembrane for hydraulic containment purposes in the last 4 years, including a list of the relevant completed facilities. Each entry in this list should include the name, location, and purpose of the facility; geomembrane thickness, total square footage, and date of installation; names of the Owner, Designer, Primary Contractor, and CQA Consultant; and the name and telephone number of a contact at the facility who can discuss the project.
- b. A copy of the Geomembrane Installer's CQA manual. This manual should describe the quality control programs for handling, deploying, placing, anchoring, seaming, repairing, and testing geomembrane. Geomembrane Installer shall modify the CQA manual to comply with the requirements of these Specifications and the project CQA Plan, with any variations, deviations, or exceptions clearly noted in an attached letter.

C. The following submittals shall be provided after award of Contract:

1. Geomembrane Manufacturer:

- a. Prior to or coincident with shipment of geomembrane to the project site, submit written certification and supporting test data documenting that all resin used for geomembrane production complies with the requirements of Part 2.01.D of this Section. This certification shall state the producer, product designation, lot or batch number, and production date of all resin used in the manufacture of geomembrane shipped to the project site and shall include copies of all quality control certificates issued by the resin producer.
- b. Prior to or coincident with shipment of geomembrane to the project site, submit written certification stating that the geomembrane and extrudate rod shipped to the project site were produced using the same resin. Include supporting test data documenting that extrudate rod complies with the requirements of Part 2.02.B of this Section.
- c. Prior to or coincident with shipment of geomembrane to the project site, submit written certification stating that all formulations used to produce geomembrane shipped to the project site comply with the requirements of Part 2.01.
- d. Prior to or coincident with shipment of geomembrane to the project site, submit written certification and supporting test data, in the form of Quality Control Certificates, documenting that all geomembrane shipped to the project site complies with the requirements of Part 2.01 of this Section. Geomembrane Quality Control Certificates must be reviewed and signed by a responsible representative of the Geomembrane Manufacturer.

2. Geomembrane Installer:

- a. Two months prior to shipment of geomembrane to the project site, submit six full sets of field installation drawings for Engineer's approval.

Installation drawings shall show the proposed length, width, and position of all geomembrane panels and the location of all field seams.

Geomembrane panels and field seams shall have distinct identification systems. Panel layouts shall avoid field seams that are parallel to and fall within pipe trenches or envelopes. Installation drawings shall also show complete details for field seaming and repairs, anchoring geomembrane at the perimeter of the installation area, and attachments to structures and other penetrations, as required.

- b. Two weeks prior to arrival at the project site, submit personnel resumes demonstrating compliance with the following:
 - 1) A minimum of one field superintendent per shift shall be designated by the Geomembrane Installer and approved by the Engineer and Owner. Each field superintendent shall have a minimum of 5 years of field experience installing LLDPE and/or HDPE geomembrane. Any change or replacement of superintendents during the project must be approved in advance by the Engineer and Owner.
 - 2) Each seaming crew shall have a designated foreman. Said foreman must have a minimum of 2 years of LLDPE and/or HDPE geomembrane installation experience and must work continuously with the seaming crew.
 - 3) Each welding technician shall have a minimum of 1,000,000 square feet of LLDPE and/or HDPE geomembrane welding experience.
- c. Within 4 weeks after completion of geomembrane installation, submit a written report containing the following:
 - 1) Written certification stating that the geomembrane has been installed in accordance with the Drawings, Specifications, and project CQA Plan.
 - 2) Product and installation warranties as required by Part 3.09 of this Section.
 - 3) Copies of daily field records and all testing documentation (trial seam testing, non-destructive testing, etc.).
 - 4) As-built drawings depicting actual geomembrane panel placement and all associated details. As-built geomembrane plans ("panel diagrams") shall be prepared at a reasonable Engineer's scale using Contractor's surveyed edge of geomembrane limits (anchor trenches, runouts, etc.), and shall accurately depict panel orientations and dimensions; all repair locations (patches, cap strips, etc.); and shall clearly identify all panel numbers, seam identification numbers, and destructive testing sample locations.

1.05 Construction Quality Assurance

- A. Geomembrane CQA will be performed by the Owner's Representative.

- B. Geomembrane CQA will be performed in accordance with these Specifications and the project CQA Plan.

Part 2 Products

2.01 LLDPE Geomembrane

- A. The geomembrane and Geomembrane Manufacturer must be approved by the Engineer and Owner prior to Contract award, as required by Part 1.04B.1 of this Section.
- B. Geomembrane shall be 40 mil LLDPE having textured upper and lower sheet surfaces. The physical, mechanical, and chemical properties of the geomembrane shall comply with the requirements of Table 1 of this Section. Textured geomembrane having smooth edge strips 6 to 8 inches in width (to facilitate field seaming) may be acceptable if the base geomembrane complies with the requirements of Table 1 of this Section and the texturing material is of the same type of polymer and formulation as the base geomembrane.
- C. Geomembrane formulation shall consist of at least 97 percent (by weight) polyethylene resin, 2 percent to 3 percent (by weight) of carbon black [added for ultraviolet (UV) radiation resistance], and a maximum of 1 percent (by weight) of other additives. No plasticizers, extenders, post-consumer resin, or other materials shall be mixed into the formulation. Regrind, rework, or trim materials may be added to the formulation if they are produced by the Geomembrane Manufacturer and are of the same formulation as the geomembrane being produced. Regrind, rework, and trim materials shall not exceed 10 percent (by weight) of the geomembrane formulation.
- D. Polyethylene resin used in the manufacture of geomembrane is to be made from virgin, uncontaminated ingredients and shall be designed and manufactured specifically for producing geomembrane. Incoming resin shall be sampled and tested in accordance with the Geomembrane Manufacturer's approved MQC manual. Testing frequencies, test procedures, and resin properties shall comply with the requirements of Table 1 of this Section. Results from the resin sampling and testing program are to be submitted to the Engineer in accordance with Part 1.04.C.1.a of this Section.
- E. During production, finished geomembrane sheet shall be sampled and tested in accordance with the Geomembrane Manufacturer's approved MQC manual. Testing frequencies, test procedures, and finished sheet properties shall comply with the requirements of Table 1 of this Section. Results from the finished sheet sampling and testing program, in the form of Quality Control Certificates, are to be submitted to the Engineer in accordance with Part 1.04.C.1.d of this Section.
- F. Geomembrane shall be produced free of holes, bubbles, blisters, scratches, undispersed raw materials, contamination by foreign matter, dimensional abnormalities, or other defects. Textured geomembrane shall generally have a uniform texturing appearance and be free from agglomerated texturing material. The Owner's Representative may reject all or portions of units (rolls) of geomembrane shipped to the project site if significant production flaws are observed.
- G. Geomembrane shall be manufactured as a continuous sheet having a minimum width of 20 feet and minimum length of 500 feet in order to reduce the amount of field seaming required during installation. No factory seaming of LLDPE geomembrane panels shall be accepted.

- H. Geomembrane shall be rolled onto hollow cores having a minimum outside diameter of 6 inches and an inside diameter large enough to allow the use of a spreader bar assembly or fork lift stinger for handling and deployment. Cores shall be of stable construction such that they support the roll without excessively deflecting, buckling, or otherwise failing during handling, transportation, and storage. Rolled geomembrane shall be secured using dedicated straps, slings, or other suitable means to facilitate handling.
- I. Each geomembrane roll shall be marked or labeled to identify the Geomembrane Manufacturer, product designation, manufacturer's lot number, manufacturer's roll number, sheet thickness, length and width of each roll, and panel number (if applicable). Roll identification numbers shall conform to the numbering system established on the Geomembrane Manufacturer's Quality Control Certificates. Labels or markings shall be legible and located so that each roll of geomembrane can be identified by examining the outside of the roll or the core ends. Markings or labels shall be weather proof.
- J. At the option of the Owner, the Engineer may inspect the geomembrane manufacturing process on a full-time basis. This inspection program would include conformance sampling as required. If requested, Geomembrane Manufacturer shall submit a production schedule to the Owner and cooperate with the Engineer during plant inspection.
- K. All raw material and finished geomembrane properties, including testing frequencies and test procedures used, shall meet the requirements of this Section. No geomembrane shall be installed until the Engineer has reviewed all certifications and supporting test data and determined that the geomembrane delivered to the project site is acceptable for use. Manufacturing records, including test data, shall be maintained by the Geomembrane Manufacturer for 2 years after acceptance of the geomembrane, and shall be made available upon request.

2.02 LLDPE Extrudate Rod

- A. Extrudate rod to be used for all extrusion seaming of the geomembrane shall be made from the same resin as the geomembrane and shall be free of contamination by moisture or other materials. Carbon black and additives shall be thoroughly dispersed throughout the extrudate rod.
- B. Extrudate rod resin and finished rod shall be sampled and tested in accordance with the Geomembrane Manufacturer's approved MQC manual. Extrudate rod resin shall meet the LLDPE geomembrane resin requirements of Table 1 of this Section. Finished extrudate rod shall meet the LLDPE geomembrane carbon black content and carbon black dispersion requirements of Table 1 of this Section. Testing frequencies and test procedures shall comply with the requirements of Table 1, as applicable. Results from the extrudate rod sampling and testing program are to be submitted to the Engineer in accordance with Part 1.04.C.1.b of this Section.

2.03 Pipe Penetration Seals

- A. Boots (sleeves and skirts) to be used for sealing all pipe penetrations in the geomembrane shall be smooth 40 mil LLDPE meeting the physical, mechanical, and chemical properties of Table 1 and the formulation and resin requirements of Part 2.01 of this Section. Factory pre-fabricated boots, produced by either the Geomembrane Manufacturer or Geomembrane Installer, are preferred for this project.
- B. Gaskets to be used for sealing boots to pipes penetrating the geomembrane shall be neoprene and meet the dimensional requirements shown on the Drawings. Neoprene adhesive shall be in accordance with the Geomembrane Manufacturer's requirements.

- C. Banding clamps to be used to attach boots to pipes penetrating the geomembrane shall be stainless steel and meet the dimensional requirements shown on the Drawings.

Part 3 Execution

3.01 Pre-Installation Meeting

- A. Prior to scheduled geomembrane installation, the Owner, Owner's Representative, and Geomembrane Installer shall attend a pre-installation meeting at the project site; Virginia Department of Environmental Quality will be notified when this meeting will be held. This meeting shall be scheduled by the Owner after receipt of Geomembrane Installer's field installation drawings.
- B. Geomembrane Installer shall be represented by both the project field superintendent and the project manager.
- C. At the pre-installation meeting, site safety and rules of operation, scheduling, methods of installation, and CQA shall be discussed. The Geomembrane Installer, Owner, and Owner's Representative shall at this time agree to the required geomembrane placement, seaming, sampling, testing and repair procedures for the project.

3.02 Shipping, Handling, and Storage

- A. Contractor is responsible for proper shipping, unloading, and storage of the geomembrane. Geomembrane damaged during shipping, unloading, or storage shall be repaired or replaced at no cost to the Owner.
- B. Geomembrane rolls shall be packaged and shipped so that no damage is caused during delivery to the project site. Geomembrane shipping shall be by open trailer so rolls can be readily unloaded at the project site by lifting directly from the trailer using slings/straps, a stinger, or a spreader bar assembly.
- C. During unloading at the project site, Contractor and Owner's Representative shall conduct a surface inspection of all geomembrane rolls for defects and damage.
- D. Extreme care shall be taken by all personnel while unloading and handling geomembrane. Equipment used to unload and handle geomembrane shall have sufficient capacity to manage the roll weight without damaging the geomembrane. Geomembrane shall only be unloaded and handled using a stinger, spreader bar assembly, or the straps/slides provided by the Geomembrane Manufacturer. Pushing, sliding, or dragging of geomembrane rolls is not permitted. Owner's Representative shall have the option of inspecting all geomembrane panels, prior to final placement, to verify that all defects or damage are identified for repair.
- E. Geomembrane shall be stored at the project site in an area(s) designated by the Owner and accepted by the Owner's Representative. Contractor shall grade the storage area so that it is reasonably level and well-drained, and shall prepare the ground surface so that it is firm, smooth, and free of stones, sticks, or other materials that may damage the geomembrane.
- F. Stacking of geomembrane rolls for storage is allowed but should not be so high that crushing of cores or flattening of rolls occurs. In general, the maximum stacking limit is three rolls high. A suitable means of securing the rolls shall be used so that shifting, abrasion, or other adverse movement does not occur. Geomembrane with folds or creases of any kind shall be rejected and removed from the project site.

- G. During storage, geomembrane shall be protected from excessive dust and mud by covering the rolls with a plastic sheet or waterproof tarpaulin. Roll labels shall remain intact and legible. Any roll of geomembrane that has no label or where the label is damaged or otherwise illegible may be rejected by the Owner's Representative.

3.03 Quality Control Conformance Testing

- A. Quality control conformance testing of the geomembrane shall be performed by the Owner's Representative at the frequencies shown in Table 1 of this Section. Conformance sampling and testing shall be completed in accordance with the project CQA Plan, with at least one sample per production lot as directed by the Engineer. A production lot is defined as a single run of geosynthetic material from the same production facility where the tooling and raw materials of production have not changed during manufacturing. Owner has the option to increase the frequency of conformance testing or to sample and test any questionable roll or lot.
- B. Conformance testing of the geomembrane shall include, but not be limited to, the following properties:
1. Core Thickness, ASTM D 5994
 2. Asperity Height, ASTM D 7466
 3. Tensile Properties, ASTM D 6693
 4. Tear Resistance, ASTM D 1004, Die C
 5. Interface Shear Strength, ASTM D 5321
 6. Puncture Resistance, ASTM D 4833
- C. Engineer may revise the test methods used for determination of conformance properties to allow for use of new or revised methods.
- D. All geomembrane conformance test results shall comply with the requirements of Tables 1 and 2 of this Section prior to installation. Any geomembrane that does not conform to these requirements shall be retested or rejected in accordance with the CQA Plan.
- E. Geomembrane that is rejected shall be removed from the project site. Sampling and conformance testing of geomembrane supplied as replacement for rejected material shall be performed by the Owner's Representative.

3.04 Deployment and Placement

- A. Geomembrane installer shall sign a letter accepting the condition of the Prepared Subgrade.
- B. Geomembrane shall be deployed and placed in general accordance with the Geomembrane Installer's approved field installation drawings. Depending on field conditions, it may be necessary to alter the geomembrane panel arrangement from that shown on the approved field installation drawings. These alterations shall be approved by the Owner's Representative prior to geomembrane deployment.
- C. Geomembrane Installer shall maintain a daily field record of actual placement of each geomembrane panel, noting subgrade conditions, weather, seaming parameters, panel numbers placed, seams completed, samples taken, and tests run. A copy of each day's field record shall be furnished to the Owner's Representative no later than the following work day.

- D. Geomembrane shall only be placed on the Cushion Geotextile that has been installed in accordance with the Drawings and Specifications, and has been accepted in writing by the Contractor, Geomembrane Installer, and Owner's Representative. Once prepared subgrade or Cushion Geotextile has been accepted by the Owner's Representative to receive geomembrane, any additional surface preparation that the Contractor or Geomembrane Installer feels necessary to meet the requirements of the Specifications shall be the responsibility of the Contractor.
- E. Cushion Geotextile shall be free of rocks, dirt, tools, or other debris before placing geomembrane. Areas the Geomembrane Installer believes exhibit deficient subgrade conditions shall be reported to the Owner's Representative and Owner for repair.
- F. It is imperative to keep surface water runoff from beneath the geomembrane at all times during installation. Geomembrane Installer's panel placement and seaming techniques and schedule shall minimize or eliminate the potential for accumulation of water beneath the geomembrane. Any water found ponded beneath the geomembrane after it has been installed shall be removed by the Contractor, as directed by the Owner's Representative. Any Prepared Subgrade beneath installed geomembrane that has become excessively moist, soft, or unsuitable to perform its intended function, shall be removed and replaced by the Contractor, as directed by the Owner's Representative.
- G. Equipment and tools used to deploy and place geomembrane shall not stretch, score, scratch, crease, or otherwise damage the geomembrane, and shall not damage any underlying Compacted Soil Liner.
- H. Under no circumstances shall any construction or vehicular traffic be allowed to drive over exposed geomembrane. Geomembrane showing evidence of trafficking shall be inspected by the Geomembrane Installer, Contractor, and Owner's Representative to evaluate damage, if any. At the direction of the Owner's Representative, any damaged geomembrane shall be tested, rejected, or repaired. Owner's Representative may allow limited use of four-wheeled all-terrain vehicles or other low ground pressure equipment (having 5 pounds per square inch or less contact pressure) by the Geomembrane Installer during installation, but use shall be prohibited if excessive trafficking or any geomembrane damage, including scratches, is observed.
- I. Geomembrane shall be unrolled and placed in such a manner as to minimize dragging of panels into position ("spotting"). Geomembrane Installer shall immediately provide temporary anchorage of the geomembrane to prevent wind uplift, panel movement during field seaming, and bridging (refer to Part 3.04.K of this Section for bridging requirements). Temporary anchorage methods shall be approved by the Engineer and Owner's Representative. If bags are used for temporary anchorage, they shall be filled with fine-grained sand that has been approved for use by the Owner's Representative. Any geomembrane exhibiting damage due to insufficient or improper temporary anchorage shall be repaired or replaced, as directed by the Owner's Representative.
- J. Geomembrane Installer shall place and seam geomembrane panels to provide adequate, well distributed slack to account for thermal expansion or contraction of the geomembrane. For this purpose, the Geomembrane Installer may use a working range of geomembrane sheet temperatures from 35 to 150 degrees Fahrenheit (°F) to determine required techniques. In critical areas such as sumps, pipe trenches, and corners, the Geomembrane Installer may propose slack control techniques for approval by the Engineer.

- K. Geomembrane shall be installed so as to minimize or eliminate bridging ("trampolining") at the toe of slopes or within pipe trenches down to temperatures as low as 32°F. Bridging control measures may include providing slack, using and maintaining additional temporary anchorage (e.g., sandbagging), or other methods approved by the Engineer. If bridging is observed, Geomembrane Installer shall repair affected areas, as directed by the Owner's Representative.
- L. Scratches on the geomembrane surface caused during geomembrane handling, deployment, or by placement or transport of geomembrane or overlying materials, shall be evaluated for repair by the Owner's Representative. Excessive scratches may result in removal and replacement of the entire affected panel.
- M. Panel seams shall be oriented in a direction parallel to the line of maximum subgrade slope (i.e., down, not across the slope) and shall be placed in a manner that minimizes the number and length of field seams. In corners and odd-shaped geometric locations, the number of field seams shall be minimized and moved to locations outside the corners as appropriate.
- N. For geomembrane placed on slopes, panels shall be shingled such that the "upstream" panel overlaps the "downstream" panel in order to minimize infiltration potential.
- O. No butt seams are permitted across sideslopes parallel to the toe of slope. Liner panels shall extend at least 10 feet beyond the toe of slope before making a longitudinal seam, except where explicitly approved by the Owner's Representative.
- P. All panel seams parallel to the toe of a slope ("longitudinal seams") shall be located at least 10 feet from the toe of the slope, except where explicitly approved by the Owner's Representative. No longitudinal seams are permitted on sideslopes.
- Q. All geomembrane panels shall be permanently seamed on the same day they are placed except where explicitly approved by the Owner's Representative.
- R. Contractor shall be responsible for excavation, maintenance, and backfilling of the geomembrane anchor trench. Backfilling of the anchor trench shall commence only after the geomembrane has had sufficient time to expand or contract into its final position and has been approved by the Owner's Representative.

3.05 Seaming

- A. Thermo-fusion seaming methods shall be used to join geomembrane panels in the field. A minimum overlap of 4 inches shall be used. Seams shall be hot wedge or extrusion welded as prescribed by the Geomembrane Manufacturer and approved by the Engineer. For joining geomembrane panels, dual hot wedge is the preferred seaming method. Extrusion seaming shall be used primarily for repairs and detailing.
- B. Geomembrane Installer shall provide the following equipment, and any required accessories, to complete geomembrane seaming. Equipment shall be provided and maintained in sufficient numbers to avoid delaying Work.
 - 1. Seaming equipment: Hot wedge (single and dual track), extrusion, and hot air ("leister") welding machines. All seaming equipment shall be equipped with gauges that clearly display wedge temperature, rate of travel, barrel temperature, and nozzle ("pre-heat") temperature, as applicable.
 - 2. Destructive testing equipment: Punch press and field tensiometer for field destructive testing of geomembrane seams. Punch press shall be capable of

- producing die-cut geomembrane specimens in accordance with ASTM D 6392. Tensiometer shall be built to applicable ASTM specifications, be in good working order, and shall be accompanied by evidence of calibration within the last year.
3. Non-destructive testing equipment: Vacuum box, air pump(s) and gauges, and voltage applicator(s) for non-destructive testing of geomembrane seams and repairs. All testing equipment shall be built to applicable ASTM specifications and be in good working order.
 4. Portable electric generators: Capable of providing constant voltage under a combined-line load. Generators must have rubber tires or be placed on a layer of cushioning material that does not damage the geomembrane.
 5. Miscellaneous equipment: Any other equipment or tools (e.g., hook blades, scissors, markers, etc.) necessary to complete geomembrane seaming, testing, and labeling in accordance with these Specifications and the Geomembrane Installer's approved CQA manual.
- C. No production seaming shall commence until trial seaming, as outlined in Part 3.05 of this Section, is successfully completed and accepted by the Owner's Representative.
- D. The Engineer and Owner, in conjunction with the Geomembrane Installer and Contractor, shall establish site-specific limits of weather conditions, including, but not limited to, temperature, humidity, precipitation, and wind speed and direction, within which geomembrane panel placement and seaming can be conducted. In the absence of site-specific criteria, the following limitations shall apply:
1. No placement or seaming shall be conducted in the presence of precipitation, such as rain, snow, sleet, dew, or fog.
 2. No placement or seaming shall be conducted in the presence of winds in excess of 20 miles per hour, when dirt or debris is blown into seaming areas, or when seaming temperatures cannot be adequately monitored and controlled.
 3. Seaming shall not be conducted when geomembrane sheet temperature falls below 35°F unless approved by the Owner's Representative. In order for seaming to be approved, Geomembrane Installer shall be required, at a minimum, to prepare additional trial seams to demonstrate conformance with these Specifications. Engineer reserves the right to require additional destructive seam testing when seaming is conducted at geomembrane sheet temperatures below 35°F. Geomembrane Installer shall be prepared to pre-heat seaming areas prior to production seaming in accordance with Geomembrane Manufacturer recommendations.
 4. Seaming shall not be conducted when geomembrane sheet temperature exceeds 150°F unless approved by the Owner's Representative. Criteria for demonstration of conformance shall be outlined by the Engineer.
- E. For purposes of monitoring production seaming, geomembrane sheet temperature shall be measured and recorded by the Owner's Representative at multiple locations along seam overlap areas.
- F. Geomembrane Installer shall not cause excessive overheating of the geomembrane during trial or production seaming. Excessive overheating is defined as any of the following:

1. Application of seaming temperatures or seaming rates that result in visible warping, deformation, or discoloration of the bottom surface of the lower geomembrane in the seam area.
 2. Seaming over an existing seam ("piggybacking"), except for repairs (patches, cap strips, etc.) which cross over existing seams.
 3. Seaming using temperatures in excess of the Geomembrane Manufacturer's recommended seaming temperatures as defined at the pre-installation meeting.
- G. All extrusion seaming material shall be of a type or types recommended by the Geomembrane Manufacturer and shall be delivered to the project site in original sealed containers or packaging, each with an indelible label bearing the manufacturer's name, manufacturer's batch or lot number, and complete directions as to proper storage and use.
- H. Storage of fuel, oils, and other petroleum products shall be restricted to off-geomembrane areas. Similarly, fueling of equipment (e.g., generators) and changing of oil and oil filters shall be restricted to off-geomembrane areas. If any fuel, oils, or other petroleum products are leaked or accidentally spilled on the geomembrane, they shall be immediately removed. The spill area shall be inspected for damage by the Contractor, Geomembrane Installer, and Owner's Representative, and any damaged geomembrane shall be repaired or replaced as directed by the Owner's Representative.
- I. Trial Seaming
1. Geomembrane Installer shall be responsible for field destructive testing of all trial seams.
 2. Trial seams shall be prepared for each piece of seaming equipment whenever any of the following conditions occur:
 - a. Shift start-up.
 - b. Every 4 to 6 hours of continuous seaming within a shift.
 - c. "Cold" restart of seaming equipment.
 - d. Change in welding technician.
 - e. Significant change in geomembrane sheet temperatures.
 - f. As required by the Owner's Representative.
 3. Trial seams shall be prepared in the presence of the Owner's Representative of CQA Personnel using the same personnel, equipment, and seaming conditions that will be used during production seaming. Field destructive test results acceptable to the Owner's Representative shall be obtained prior to performing any production seaming. This may require resampling of completed trial seams or repeating the trial seam process, as directed by the Owner's Representative.
 4. Trial seams shall have a minimum length of 6 feet and minimum width of one-foot, with the seam centered across the width. Geomembrane Installer shall cut the trial seam into two equal length samples suitable for testing. One sample shall be kept by the Geomembrane Installer for destructive testing at the project site in the presence of the Owner's Representative. The duplicate sample shall be furnished to the Owner's Representative for the project record and possible future testing. Geomembrane Installer shall mark the duplicate sample with the date, time,

ambient temperature, seaming machine identification, seaming technician initials, and seaming parameters (set temperature, rate of travel, etc.) used to prepare the trial seam.

5. Trial seam samples shall be destructively tested in peel and shear in accordance with the Geomembrane Installer's approved CQA manual. A minimum of four specimens shall be tested in peel and one in shear for each trial seam. For dual hot wedge seams, four specimens must be tested in peel for each external seam track. Test specimens shall be die cut by the Geomembrane Installer using a die and punch press capable of producing specimens in accordance with ASTM D 6392. Specimens shall be cut from the center two-thirds of the trial seam sample once it has cooled to ambient temperature.
6. Qualification criteria for all trial seam destructive testing are summarized in Table 3 of this Section. Acceptable failure of seam specimens shall be in the geomembrane sheet, not within the seam itself. A partial seam separation ("peel incursion") during testing will be accepted as indicated in Table 3. Excessive peel incursion within the seam area shall constitute disqualification even if strength criteria are met. If any specimens fail to meet qualification criteria, Owner's Representative may have additional specimens from the sample tested in order to determine trial seam acceptance. Failures attributed to excessive grinding beyond weld bead areas for extrusion seams may require retesting or preparation of a new trial seam, as directed by the Owner's Representative.
7. If a trial seam fails to meet all qualification criteria, a new trial seam must be prepared. If this second trial seam also fails, the seaming equipment and/or seaming technician preparing the trial seams shall not be allowed to perform production seaming until any deficiencies are corrected and two consecutive trial seams meeting all qualification criteria are prepared and accepted by the Owner's Representative.
8. Trial seam test results shall be recorded in the Geomembrane Installer's "preweld" test log or daily field record and a copy furnished to the Owner's Representative no later than the following work day. Specimens tested by the Geomembrane Installer shall be marked and stored on the project site for inspection by the Engineer or Owner.

J. Production Seaming

1. No production seaming shall commence until trial seaming, as outlined in Part 3.05.I of this Section, is successfully completed and accepted by the Owner's Representative.
2. All geomembrane panels shall be permanently seamed on the same day they are placed except where explicitly approved by the Owner's Representative.
3. Geomembrane that is to be hot wedge seamed shall be prepared as follows:
 - a. Position geomembrane sheets to create a minimum overlap of 4 inches. If the overlap is excessive, excess geomembrane shall be trimmed from the lower sheet where possible. If excess geomembrane is trimmed from the upper sheet, Geomembrane Installer shall not scratch or score the lower sheet. Geomembrane damaged during trimming may be removed and the panel overlap reset, as directed by the Owner's Representative.

- b. Temporarily anchor sheets in a manner approved by the Owner's Representative to prevent movement during seaming and to maintain a "flat" lap of sheets. No glue or tape shall be used to temporarily hold sheets together before seaming.
 - c. Prepare overlap area to provide a suitable welding surface. Overlap area shall be free of dirt, dust, moisture, or other foreign material. No solvents shall be used to clean geomembrane sheets prior to seaming.
 - d. Seaming shall be completed as soon as is practical after preparation and cleaning is completed.
- 4. Geomembrane that is to be extrusion seamed shall be prepared as follows:
 - a. Position geomembrane sheets to create a minimum overlap of 4 inches.
 - b. Grind the edge of the upper geomembrane sheet to a 45 degree bevel using a disc grinder or equivalent tool. Lift the upper geomembrane sheet away from the lower sheet during beveling to prevent gouging of the lower sheet.
 - c. Temporarily bond geomembrane sheets, using hot air ("leister") equipment, to prevent movement during seaming and to maintain a "flat" lap of sheets. No glue or tape shall be used to temporarily hold sheets together before seaming. Overheating of the geomembrane during temporary bonding shall result in rejection of the seam or repair in question and shall be repaired as directed by the Owner's Representative.
 - d. Grind geomembrane surfaces that are to receive the extrusion weld bead, using a disc grinder or equivalent tool, no more than 15 minutes prior to seaming. Grinding area shall extend no more than 0.25-inch beyond the extrusion weld bead area and the grinding depth shall not exceed 10 percent of the geomembrane sheet thickness. Extrusion seam ends that are more than 5 minutes old shall be ground prior to joining or extending the seam. All geomembrane residue generated during grinding shall be cleared from the seaming area.
 - e. Prior to extrusion seaming, Owner's Representative shall visually inspect all prepared geomembrane surfaces to verify that excessive grinding has not occurred and that the upper geomembrane sheet is properly beveled. Owner's Representative may require repair of areas exhibiting excessive grinding or improper beveling, which may include removal and replacement of affected geomembrane.
- 5. Extrusion welding machines are to be purged of all heat-degraded extrudate prior to seaming. During seaming operations, extrudate purging will be required whenever the welding machine is idle for more than two minutes, or as directed by the Owner's Representative.
- 6. No folds, wrinkles, or "fish-mouths" shall be allowed within any seam areas. Where wrinkles or folds occur, the material shall be cut, overlapped, and a patch applied. During wrinkle or fold repairs, adjacent geomembrane may not be required to meet the 4-inch minimum overlap, if approved by the Owner's Representative.

K. Non-Destructive Testing

1. Geomembrane Installer shall be responsible for non-destructive testing of the entire length (100 percent) of all production seams and repairs to verify their continuity. Non-destructive testing shall be conducted as geomembrane seaming and repair work progresses and shall be performed in the presence of the Owner's Representative or CQA Personnel.
2. Non-destructive test methods shall include the vacuum test, air-pressure test, spark test, or other methods approved by the Engineer. Non-destructive testing procedures shall be described in the Geomembrane Installer's approved CQA manual and shall comply with all requirements of these Specifications and the project CQA Plan.
3. Seams or portions of seams that cannot be non-destructively (vacuum or air pressure) tested due to access constraints or other reasons shall be spark tested. Cap strips may be used only with the approval of the Owner's Representative.
4. Geomembrane Installer shall submit copies of all non-destructive testing documentation to the Engineer in accordance with Part 1.04.C.2.c of this Section.

L. Destructive Testing

1. Laboratory destructive testing of production seams is the responsibility of the Owner's Representative. Field destructive testing of production seams is the responsibility of the Geomembrane Installer. Geomembrane Installer is also responsible for obtaining samples and repairing sampling locations for all laboratory and field destructive testing.
2. Destructive testing sample locations shall be repaired in accordance with Part 3.06 of this Section.
3. Production seam samples suitable for laboratory destructive testing shall be obtained by the Geomembrane Installer at locations established by the Owner's Representative as production seaming progresses. All seaming equipment and welding technicians will be representatively sampled at a rate of one sample per 1,000 linear feet of production seam or a minimum of one per day as deemed necessary by the Owner's Representative. Additional samples shall be obtained by the Geomembrane Installer from areas of questionable integrity, as directed by the Owner's Representative.
4. Laboratory destructive testing samples shall have a minimum length of 3 feet and minimum width of one-foot, with the seam centered across the width. Geomembrane Installer shall cut the destructive sample into two equal length samples suitable for testing. Both samples shall be furnished to the Owner's Representative, who will forward one sample to a Geosynthetics CQA Laboratory where it shall be destructively tested in peel and shear in accordance with ASTM D 6392. The duplicate sample shall be retained by the Owner's Representative for the project record and possible future testing. An additional duplicate destructive sample may be obtained and retained for testing by the Geomembrane Installer at the Installer's discretion.
5. Qualification criteria for all production seam destructive testing are summarized in Table 3 of this Section. Acceptable failure of seam specimens shall be in the geomembrane sheet, not within the seam itself. A partial seam separation ("peel

incursion”) during testing will be accepted as indicated in Table 3. Excessive peel incursion within the seam area shall constitute disqualification even if strength criteria are met. If any specimens fail to meet qualification criteria, Owner’s Representative may have additional specimens from the sample tested in order to determine production seam acceptance. Failures attributed to excessive grinding beyond weld bead areas for extrusion seams may require resampling and retesting, as directed by the Owner’s Representative. Owner’s Representative shall determine acceptance of any destructive testing in cases of dispute.

6. If a destructive test sample fails to meet all qualification criteria, Geomembrane Installer shall obtain additional production seam samples for laboratory destructive testing as required by the project CQA Plan. Testing of these samples shall be performed by the Owner’s Representative at the Geomembrane Installer’s expense. Resampling and associated repairs shall be the responsibility of the Geomembrane Installer at no cost to the Owner.
7. In order for a production seam to be accepted, a failed destructive test sample shall be bounded by two passing destructive test samples, and the seam between the two passing test locations shall be reconstructed. Alternatively, the entire length of the seam in question may be repaired by placement of a cap strip, or by another repair procedure, as directed by the Owner’s Representative.
8. The Owner’s Representative, Engineer, or Owner may require that additional destructive test samples be taken at random locations from production seams completed during the same work shift as a failing destructive test sample or in areas that visually appear defective or not in accordance with these Specifications. Testing of these samples shall be performed by the Owner’s Representative, but obtaining the samples and repairing the sampling locations shall be the responsibility of the Geomembrane Installer.

3.06 Repairs

- A. During installation, Geomembrane Installer and Owner’s Representative and CQA Personnel shall visually inspect all geomembrane panels and seams for damage, defects, or non-compliance with the Drawings and Specifications, and shall mark any such areas for repair. Geomembrane Installer shall repair marked areas as soon as possible. Any defects that could allow surface water runoff beneath the geomembrane shall be repaired on the same day they are marked.
- B. Acceptable geomembrane repair methods include:
 1. Patching: For repair of surface defects, small tears, punctures, destructive sampling locations, etc. Patches shall have a minimum size of 12 inches by 12 inches, extend at least 6 inches beyond the edge(s) of a defect, and have rounded corners so that the repair may be completed with a continuous extrusion seam. In some cases, the Owner’s Representative may direct the Geomembrane Installer to cut out and remove a defect prior to patching in order to minimize the risk of crack propagation.
 2. Spot welding (“bead repairs”): For repair of pinholes or other minor, localized defects. Spot welding shall only be permitted where explicitly approved by the Owner’s Representative prior to performing the repair.

3. Reconstruction: For repair of lengths (segments) of unacceptable seams. Performed by cutting and removing the unacceptable seam segment and replacing it with new geomembrane that is seamed into place.
 4. Cap stripping: For repair of lengths (segments) of unacceptable seams in lieu of reconstruction. Cap strips shall extend at least 12 inches beyond the edge(s) of a seam, and have rounded corners so that the repair may be completed with a continuous extrusion seam.
 5. Flap seaming: For repair of small lengths of unacceptable hot wedge seams in lieu of cap stripping. Performed by extrusion seaming the excess upper geomembrane flap of a hot wedge seam to the lower geomembrane sheet. Flap seaming shall only be permitted when the affected area is less than 10 feet in length and is explicitly approved by the Owner's Representative prior to performing the repair.
 6. Grinding and reseaming: For repair of small lengths of unacceptable extrusion seams in lieu of cap stripping. Grinding and reseaming shall only be permitted when the affected area is less than 3 feet in length and is explicitly approved by the Owner's Representative prior to performing the repair.
- C. Under no circumstances shall seams be repaired by placing extrusion seams directly atop previously seamed areas ("piggybacking").
- D. Seam intersections ("tees") shall be covered with a patch meeting the requirements of Part 3.06.B.1 of this Section, except where explicitly approved by the Owner's Representative prior to performing the repair.
- E. Owner's Representative may require repair or replacement of any area where excessive grinding, overheating, or unacceptable preparation, seaming or testing techniques are observed. Such repair or replacement may be required even if samples removed from affected areas pass destructive testing.
- F. All repairs shall be non-destructively tested by the Geomembrane Installer in accordance with Part 3.05.K of this Section.

3.07 Pipe Penetration Seals

- A. Pipe penetrations in the geomembrane shall be sealed using LLDPE pipe boots (sleeves and skirts), neoprene gaskets, and stainless steel banding straps, as shown on the Drawings and specified in Part 2.03 of this Section.
- B. Surfaces where pipe boots are to be attached (including HDPE pipe) shall be cleaned to remove dirt, oil, debris, or other deleterious materials. Geomembrane and HDPE pipe surfaces that will be extrusion seamed to a pipe boot are to be prepared in accordance with Part 3.05.J.4 of this Section.
- C. Prior to attaching and/or seaming pipe boots, Owner's Representative shall visually inspect all prepared surfaces to verify that proper preparation techniques have been followed. The Owner's Representative may require repair of areas exhibiting improper preparation techniques or damage, which may include removal and replacement of affected geomembrane or pipe.
- D. Geomembrane Installer shall be responsible for non-destructive testing of the entire length (100 percent) of all pipe boot extrusion seams to verify their continuity. Non-destructive testing shall be performed in the presence of the Owner's Representative and in accordance with Part 3.05.K of this Section.

3.08 Final Inspection, Acceptance, and Covering

- A. A final visual examination of all geomembrane panels, seams, repairs, and pipe penetration seals shall be completed by the Owner's Representative prior to accepting geomembrane. Owner's Representative's inspection shall only be performed following a complete inspection and approval by the Geomembrane Installer's field superintendent or designated quality control technician. Contractor shall be responsible for cleaning, sweeping, or other measures necessary to provide a thoroughly visible geomembrane surface for the Owner's Representative's inspection.
- B. Geomembrane Installer shall repair and test any areas identified during the Owner's Representative's final inspection as not being in accordance with the Drawings and Specifications.
- C. No geomembrane shall be covered until it has been accepted by the Owner's Representative in writing. Once accepted, geomembrane shall be covered within 5 calendar days of acceptance in accordance with the Drawings and Specifications.
- D. If textured geomembrane is to be covered with other geosynthetics (e.g., geotextile), a smooth temporary geosynthetic covering ("slip sheet") shall be used to protect both the geomembrane and overlying geosynthetic from damage until the overlying geosynthetic is in its final position for seaming.

3.09 Warranties

- A. Contractor shall be responsible for obtaining any necessary guarantees or certifications from the Geomembrane Manufacturer and Geomembrane Installer and submitting them to the Engineer and Owner prior to acceptance of installed geomembrane.
- B. Contractor shall guarantee the integrity, within the realm of limitations of Contractor's responsibility, of the installed geomembrane for its intended use, from installation defects for a period of 2 years from the date of geomembrane installation, and from manufacturing defects for a period of 20 years from the date of geomembrane installation. Such written warranties shall provide for the total and complete repair and/or replacement of any defect or defective areas of geomembrane upon written notification and demonstration by the Owner of the specific non-conformance of the geomembrane or installation with the Drawings and Specifications. Such defects or non-conformance shall be repaired and/or replaced expeditiously.

Table 1
Required Properties of Textured 40 Mil LLDPE Geomembrane⁽¹⁾

Property (Units)	MQC Testing Frequency (Minimum)	Test Method ⁽²⁾	Required Value
Resin			
Density (g/cc)	1 per Resin Batch	ASTM D 1505 or D 792	0.939
Melt Flow Index (g/10 min)	1 per Resin Batch	ASTM D 1238, Condition 190/2.16	1.0 (max)
Finished Sheet			
Core Thickness (mil)	Each roll	ASTM D 5994	38 (min ave) ⁽³⁾
Asperity Height (mil)	Every second roll	ASTM D 7466	16 (min ave) ⁽⁴⁾
Density, (g/cc)	Every 200,000 lbs	ASTM D 1505 or D 792	0.939 (max ave)
Carbon Black Content (%)	Every 45,000 lbs	ASTM D 1603 ⁽⁵⁾	2.0-3.0
Carbon Black Dispersion	Every 45,000 lbs	ASTM D 4218	Categories 1 or 2 ⁽⁶⁾
Tensile Properties (each direction) Break Strength (lb/in) Break Elongation (%)	Every 20,000 lbs	ASTM D 6693 Type IV Test in machine direction and cross-machine direction	103(min ave) 400 (min ave)
Tear Resistance (lb)	Every 45,000 lbs	ASTM D 1004	22 (min ave)
Puncture Resistance (lb)	Every 45,000 lbs	ASTM D 4833	48 (min ave)
Oxidative Induction Time (mins) ⁽⁷⁾ Standard OIT	Every 200,000 lbs	ASTM D 3895	100 (min ave)
Oven Aging at 85 degrees Celsius (°C) High Pressure OIT (percent retained after 90 days)	Per each formulation	ASTM D 5885	60 (min ave)
UV Resistance ⁽⁸⁾ High Pressure OIT (percent retained after 1,600 hours)	Per each formulation	ASTM D 5885	35 (min ave)

Notes:

- (1) The required properties specified herein may be revised by the Engineer to reflect new or revised test methods or to conform with improvements to the state-of-the practice.
- (2) Number of specimens per test established in applicable test method unless otherwise noted.
- (3) Lowest individual value for eight out of 10 readings = 36 mil; lowest individual value for one out of 10 readings = 34 mil.
- (4) Alternate side of sheet measured each time a roll is tested.
- (5) ASTM Method D 4218 is acceptable if an appropriate correlation to D 1603 can be established.
- (6) For 10 different views: nine in Categories 1 or 2 and one in Category 3. Only near spherical agglomerates are to be considered.
- (7) Geomembrane Manufacturer may select either of the OIT methods listed to evaluate antioxidant content.
- (8) Condition of test should be 20-hour UV cycle at 75°C followed by 4-hour condensation at 60°C.

Table 2
Interface Shear Strength Requirements for Textured 40 Mil LLDPE Geomembrane^(1, 2, 3, 4)

Testing Set-Up		
ASTM D5321	Conditioning:	Set up each test to match field placement orientation. Run all tests under wet conditions.
	• Procedure A:	Geomembrane against Cushion Geotextile Substrate: Project Cushion Geotextile Superstratum: Project Textured 40 Mil LLDPE Geomembrane Displacement Rate: 0.04-inch per minute (ipm) (maximum) Total Displacement: 2.50 in (minimum)
	• Procedure B:	Geomembrane against GDN Substrate: Project Textured 40 Mil LLDPE Geomembrane Superstratum: Project GDN Displacement Rate: 0.04 ipm (maximum) Total Displacement: 2.50 in (minimum)
	• Procedure C:	Geomembrane against Prepared Subgrade Substrate: Project Textured 40 Mil LLDPE Geomembrane Superstratum: Project Prepared Subgrade Displacement Rate: 0.04 ipm (maximum) Total Displacement: 2.50 in (minimum)
	• Special Instructions:	None.
Strength Requirements		
Normal Stress [Pounds per Square Foot (psf)]		Minimum Peak Shear Strength
150		20 Degrees
300		
600		
1000		

Notes:

- (1) Table 2 testing shall be performed by the Owner's Representative.
- (2) Test individual interfaces between Steel rasp platens. In lieu of testing individual interfaces, a system test may be performed using a configuration that allows failure to occur through the weakest shearing plane. System test configuration, conditions, and procedures must be accepted by the Engineer prior to submitting test results for review and approval. Testing frequency as per CQA Plan.
- (3) Interfaces shall be saturated for a minimum of 24 hours prior to testing.
- (4) Geosynthetics shall be oriented such that the shear force is parallel to the down slope orientation of these components in the field.

Table 3
Seam Qualification Criteria for Textured 40 Mil LLDPE Geomembrane⁽¹⁾

	Trial Seaming^(1, 3)	Production Seaming^(2, 3, 4)
Hot Wedge Seams		
Peel Strength (lbs/in)	50	50
Peel Incursion (%)	25	25
Shear Strength (lbs/in)	60	60
Shear Elongation at Break (%)	----	50
Extrusion Fillet Seams		
Peel Strength (lbs/in)	44	44
Peel Incursion (%)	25	25
Shear Strength (lbs/in)	60	60
Shear Elongation at Break (%)	----	50

Notes:

- (1) Field test in accordance with project Specifications and CQA Plan.
- (2) Laboratory test in accordance with ASTM D 6392. For production seaming, values listed for shear and peel strengths are for four out of five test specimens; the fifth specimen can be as low as 80 percent of the listed value.
- (3) Seam tests for peel and shear must fail in the Film Tear Bond mode. This is a failure in the ductile mode of one of the bonded sheets by tearing or breaking prior to complete separation of the bonded area.
- (4) Where applicable, both tracks of a double hot wedge seam shall be tested for peel strength.

-End of Section-

SECTION 02598

Geosynthetic Clay Liner

Section 02598 Geosynthetic Clay Liner

Part 1 General

1.01 Summary

- A. All supervision, labor, products, equipment, and tools, shall be furnished including all necessary and incidental items as detailed or required, to install GCL in accordance with the Contract Drawings, Specifications, and project CQA Plan.
- B. GCL perimeter liner termination area shall be excavated, maintained, ballasted, and backfilled.

1.02 References

- A. ASTM Standards:
 - 1. D 4632, "Standard Test Method for Grab Breaking Load and Elongation of Geotextiles".
 - 2. D 4643, "Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method".
 - 3. D 5261, "Standard Test Method for Measuring Mass per Unit Area of Geotextiles".
 - 4. D 5887, "Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Using a Flexible Wall Permeameter".
 - 5. D 5888, "Standard Guide for Storage and Handling of Geosynthetic Clay Liners".
 - 6. D 5889, "Standard Practice for Quality Control of Geosynthetic Clay Liners".
 - 7. D 5890, "Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners".
 - 8. D 5891, "Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners".
 - 9. D 5993, "Standard Test Method for Measuring Mass per Unit of Geosynthetic Clay Liners".
 - 10. D 6072, "Standard Guide for Obtaining Samples of Geosynthetic Clay Liners".
 - 11. D 6102, "Standard Guide for Installation of Geosynthetic Clay Liners".
 - 12. D 6243, "Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method".
 - 13. D 6495, "Standard Guide for Acceptance Testing Requirements for Geosynthetic Clay Liner".
 - 14. D 6496, "Standard Test Method for Determining Average Bonding Peel Strength between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners".

1.03 Definitions

- A. MARV: Minimum Average Roll Value. For geosynthetics, the value calculated as the typical value minus two standard deviations from documented quality control test results for a defined population from one specific test method associated with one specific property.

1.04 Submittals

- A. Submittals shall be submitted in a timely fashion for review.

B. The following submittals shall be provided with Contractor's Bid:

1. The GCL and GCL Manufacturer must be approved prior to material shipment. Submittals for approval include:

- a. GCL Manufacturer's specification sheet(s) demonstrating compliance with the requirements of Table 1 of this Section.
- b. GCL Manufacturer's historical data for 10,000 hour large-scale constant load ("creep") shear testing. Creep testing shall have been performed on hydrated reinforced GCL at a normal stress of 500 psf and at a constant shear stress of 250 psf.

C. Written certification that the GCL Manufacturer has produced a minimum of 10,000,000 square feet of GCL that has been installed for hydraulic containment purposes in the last 4 years, including a list of the relevant completed facilities. Each entry in this list should include the name, location, and purpose of the facility; GCL product designation, total square footage, and date of installation; Designer, and GCL Installer; and the name and telephone number of a contact at the facility who can discuss the project.

D. A copy of the GCL Manufacturer's MQC manual. This manual should describe the quality control program(s) for GCL components (bentonite clay, geotextiles, etc.) and finished GCL, and indicate the properties, test methods, and testing frequencies used for each. GCL Manufacturer shall modify the MQC manual to comply with the requirements of these Specifications, with any variations, deviations, or exceptions clearly noted in an attached letter.

1. The GCL Installer must be approved prior to material shipment. Submittals for approval include:

- a. Written certification that the GCL Installer has installed a minimum of 2,000,000 square feet of GCL for hydraulic containment purposes in the last 2 years, including a list of the relevant completed facilities. Each entry in this list should include the name, location, and purpose of the facility; GCL product designation, total square footage, and date of installation; Designer, and the name and telephone number of a contact at the facility who can discuss the project.
- b. A copy of the GCL Installer's CQA manual. This manual should describe the quality control program(s) for handling, deploying, anchoring, seaming, and repairing GCL. GCL Installer shall modify the CQA manual to comply with the requirements of these Specifications and the project CQA Plan, with any variations, deviations, or exceptions clearly noted in an attached letter.

E. The following submittals shall be provided after award of material shipment:

1. GCL Manufacturer:

- a. Prior to or coincident with shipment of GCL to the project site, submit written certification and supporting test data, in the form of Quality Control Certificates, documenting that all GCL components (sodium bentonite and non-woven geotextile) and finished GCL shipped to the project site comply with the requirements of Part 2.01 of this Section. GCL Quality Control Certificates must be reviewed and signed by a responsible representative of the GCL Manufacturer and shall include copies of all

quality control certificates issued by the sodium bentonite and non-woven geotextile manufacturers.

- b. Prior to or coincident with shipment of GCL to the project site, submit written certification stating that the GCL and accessory bentonite shipped to the project site were produced using the same sodium bentonite. Include supporting test data documenting that accessory bentonite complies with the requirements of Parts 2.01 and 2.02 of this Section.

2. GCL Installer:

- a. Four weeks prior to shipment of GCL to the project site, submit field installation drawings for approval. Installation drawings shall show the proposed length, width, and position of all GCL panels and the location of all side seams. Installation drawings shall also show complete details for any proposed alternative installation methods. If any proposed alternative installation details are not accepted the details provided on the construction drawings will be used.
- b. Within 1 week after completion of GCL installation, submit a written report containing the following:
 - 1) Written certification stating that the GCL has been installed in accordance with the Contract Drawings, Specifications, and project CQA Plan;
 - 2) Product and installation warranties as required by Part 3.08 of this Section; and
 - 3) Copies of daily field records.

1.05 CQA and Quality Assurance

- A. GCL CQA will be performed by the GCL Installer in accordance with the CQA manual approved.
- B. GCL CQA will be performed in accordance with these Specifications and the project CQA Plan.

Part 2 Products

2.01 GCL

- A. The GCL and GCL Manufacturer must be approved prior to Contract award, as required by Part 1.04 of this Section.
- B. GCL shall consist of a layer of sodium bentonite clay encapsulated between two non-woven needle-punched PP geotextiles, and shall be fully needle-punched throughout to provide internal shear reinforcement. The physical, mechanical, and chemical properties of the reinforced GCL shall comply with the requirements of Table 02598-1 of this Section.
- C. Sodium bentonite used in the manufacture of GCL is to be processed specifically for producing GCL. Incoming sodium bentonite shall be sampled and tested in accordance with the GCL Manufacturer's approved MQC manual. Testing frequencies, test procedures, and sodium bentonite properties shall comply with the requirements of Contractor of this Section. Results from the sodium bentonite sampling and testing program are to be submitted in accordance with Part 1.04 of this Section.

- D. Geotextile used in the manufacture of GCL shall be non-woven needle-punched PP meeting the physical, mechanical, and chemical property requirements of Table 02598-1 of this Section. PP resin used in the manufacture of geotextile is to be made from virgin, uncontaminated ingredients and shall be designed and manufactured specifically for producing geotextile. Geotextile formulations shall contain no plasticizers, fillers, extenders, or PCR. During production, geotextile shall be continuously inspected for the presence of broken needles, which shall be removed from the finished product. Geotextile shall be sampled and tested, prior to incorporation into finished GCL, in accordance with the GCL Manufacturer's approved MQC manual. Testing frequencies, test procedures, and geotextile properties shall comply with the requirements of Table 02598-1 of this Section. Results from the geotextile sampling and testing program are to be submitted in accordance with Part 1.04 of this Section.
- E. During production, finished GCL shall be sampled and tested in accordance with the GCL Manufacturer's approved MQC manual. Testing frequencies, test procedures, and finished GCL properties shall comply with the requirements of Table 02598-1 of this Section. Results from the finished GCL sampling and testing program, in the form of Quality Control Certificates, are to be submitted in accordance with Part 1.04 of this Section.
- F. GCL shall be produced free of holes, tears, contamination by foreign matter, dimensional abnormalities, or other defects. During production, GCL shall be continuously inspected for the presence of broken needles, which shall be removed from the finished product. All or portions of units (rolls) of GCL shipped to the project site may be rejected if significant production flaws are observed.
- G. GCL shall be manufactured as a continuous panel having a nominal width of 14.5 feet and minimum length of 150 feet in order to reduce the amount of field seaming required during installation. Rolls of GCL having lengths shorter than 150 feet may be shipped to the project site if the number of such rolls is approved prior to shipment.
- H. GCL shall be rolled onto hollow cores having a minimum inside diameter of 4 inches to allow the use of a stinger or spreader bar assembly for handling and deployment. Cores shall be of stable construction such that they support the roll without excessively deflecting, buckling, or otherwise failing during handling, transportation, and storage. Each roll of GCL shall be protected by wrapping it in packaging that is waterproof, resistant to photo degradation by UV light, and completely covers all exposed GCL surfaces and edges.
- I. Each GCL roll shall be labeled to identify the GCL Manufacturer, product designation, manufacturer's batch or lot number, manufacturer's roll number, and the length, width, and weight of each roll. Roll identification numbers shall conform to the numbering system established on the GCL MQC Certificates. Labels shall be weather proof, legible, and located so that each roll of GCL can be identified by examining the outside of the roll or the core ends.
- J. The GCL manufacturing process may be inspected on a full-time basis. This inspection program would include conformance sampling as required. If requested, GCL Manufacturer shall submit a production schedule during plant inspection.
- K. All GCL components and finished GCL properties, including testing frequencies and test procedures used, shall meet the requirements of this Section. Manufacturing records, including test data, shall be maintained by the GCL Manufacturer for 2 years after acceptance of the GCL, and shall be made available upon request.

2.02 Accessory Bentonite

- A. Granular bentonite sealing clay or bentonite mastic to be used for overlap seaming, penetration sealing, and repairs shall be made from the same sodium bentonite as used in the GCL.
- B. Accessory bentonite shall be sampled and tested in accordance with the GCL Manufacturer's approved MQC manual. Accessory bentonite shall meet the sodium bentonite requirements of Table 02598-1 of this Section. Testing frequencies and test procedures shall comply with the requirements of Table 02598-1, as applicable. Results from the accessory bentonite sampling and testing program are to be submitted in accordance with Part 1.04 of this Section.

Part 3 Execution

3.01 Pre-Installation Meeting

- A. Prior to scheduled GCL installation, a pre-installation meeting at the project site shall occur. This meeting shall be scheduled after receipt of GCL Installer's field installation drawings.
- B. GCL Installer shall be represented by both the project field superintendent and the project manager.
- C. At the pre-installation meeting, site safety and rules of operation, scheduling, methods of installation, and CQA and quality assurance shall be discussed. All parties shall at this time agree to the required GCL placement, seaming, and repair procedures for the project.

3.02 Shipping, Handling, and Storage

- A. GCL damaged during shipping, unloading, or storage shall be repaired or replaced.
- B. GCL rolls shall be packaged and shipped so that no damage, including hydration, is caused during delivery to the project site. GCL shipping shall be by open or enclosed trailers loaded in such a manner that rolls can be readily unloaded at the project site using a stinger or spreader bar assembly. GCL rolls shipped by open trailer shall be protected with a sacrificial or temporary cover during shipment.
- C. During unloading at the project site, a surface inspection of all GCL rolls shall be conducted for defects and damage, including damage to the original protective packaging. Any defects or damage observed shall be notified immediately.
- D. Extreme care shall be taken by all personnel while unloading and handling GCL. Equipment used to unload and handle GCL shall have sufficient capacity to manage the roll weight without damaging the GCL. GCL shall only be unloaded and handled using a stinger or spreader bar assembly meeting the requirements of ASTM D 5888 or as recommended by the GCL Manufacturer. Pushing, sliding, or dragging of GCL rolls is not permitted. CQA Personnel shall have the option of inspecting all GCL panels, prior to final placement, to verify that all defects or damage are identified for repair.
- E. The storage area shall be graded so that it is reasonably level and well drained, and shall prepare the ground surface so that it is firm, smooth, and free of stones, sticks, or other materials that may damage the GCL.
- F. GCL rolls shall be stored off the ground and continuously supported along their length. Stacking of GCL rolls for storage is allowed but should not be so high that crushing of

cores, flattening of rolls, or thinning of the GCL occurs. In general, the maximum stacking limit is three rolls high. A suitable means of securing the rolls shall be used so that shifting or other adverse movement does not occur.

- G. During storage, GCL rolls and accessory bentonite shall be protected from moisture, direct sunlight, mud, and excessive dust by covering them with a plastic sheet or waterproof tarpaulin. Roll labels shall remain intact and legible. Any roll of GCL that has no label or where the label is damaged or otherwise illegible may be rejected by the CQA Consultant. GCL rolls shall be kept in their original protective packaging until immediately before they are to be deployed.

3.03 Quality Assurance Conformance Testing

- A. Quality assurance conformance testing of the GCL shall be performed. Conformance sampling and testing shall be completed in accordance with the project CQA Plan, with at least one sample per production lot as directed. The frequency of conformance testing may be increased to sample and test any questionable roll or lot.
- B. Conformance testing of the GCL shall include, but not be limited to, the properties listed on Table 02598-1.
- C. The test methods used for determination of conformance properties may be revised to allow for use of new or revised methods.
- D. All GCL conformance test results shall comply with the requirements of Table 02598-1 of this Section prior to installation. Any GCL that does not conform to these requirements shall be retested or rejected in accordance with the CQA Plan.
- E. GCL that is rejected shall be removed from the project site and replaced. Sampling and conformance testing of GCL supplied as replacement for rejected material shall be performed.

3.04 Deployment and Placement

- A. The GCL liner installation shall not begin until the low permeability clay liner surface and CCR surface have been prepared to accept the GCL liner. The low permeability clay liner and CCR surfaces shall be maintained in a firm and dry condition during the installation of GCL liner.
- B. The Contractor and Installer shall provide to the Owner's Representative a certificate of acceptance of the soil liner layer surface for each area of installation as stated in 1.04.
- C. It shall be the Contractor's responsibility after written acceptance to indicate to the ENGINEER any change in the condition of the low permeability clay liner surface that could cause the low permeability clay liner surface to be out of compliance with any of the requirements listed in these specifications. The Contractor shall perform repair(s) at no additional costs to the OWNER.
- D. GCL shall be deployed and placed in general accordance with the GCL Installer's approved field installation drawings. Depending on field conditions, it may be necessary to alter the GCL panel arrangement from that shown on the approved field installation drawings. These alterations shall be approved prior to GCL deployment.
- E. Site-specific limits of weather conditions shall be established, including, but not limited to, temperature, precipitation, and wind speed and direction, within which GCL panel placement can be conducted. Acceptable weather conditions will be governed by the geomembrane used to cover the GCL.

- F. GCL Installer shall maintain a daily field record of actual placement of each GCL panel, noting GCL subbase conditions, weather, panel numbers placed, and seaming methods. A copy of each day's field record shall be furnished to the CQA Consultant no later than the following workday.
- G. Surfaces (low permeability clay liner surface and CCRs) that are to receive GCL shall be prepared in accordance with the Contract Drawings and Specifications. GCL Installer shall install GCL only on surfaces that have been approved in writing.
- H. GCL Installer shall coordinate placement of GCL with placement of the covering material (geomembrane and Protective Cover Soil). All GCL panels shall be covered with geomembrane and Protective Cover Soil as soon as possible after they are placed. Only as much GCL shall be deployed as can be covered by Protective Cover Soil (meeting the requirements of Earthwork Section of the Specifications) in the same workday. No GCL shall be allowed to remain exposed at the end of a workday. Any GCL that becomes hydrated prior to placement of covering Protective Cover Soil shall be removed and replaced, unless otherwise approved by the Owner's Engineer. It is imperative to keep surface water runoff from contacting the GCL at all times during installation. GCL Installer's panel placement techniques and schedule shall minimize or eliminate the potential for accumulation of water beneath or atop the GCL. Any water found ponded on or beneath the GCL after it has been installed shall be removed. Any surface beneath installed GCL that has become excessively moist, soft, or unsuitable to perform its intended function, shall be removed. Any GCL that becomes hydrated due to surface water runoff shall be removed and replaced.
- I. Extreme care shall be taken by all personnel while handling, unwrapping, deploying, and placing GCL. Equipment and tools used shall not stretch, tear, or otherwise damage the GCL, and shall not cause rutting or other damage to the underlying surface. Equipment shall have sufficient capacity to manage the roll weight without damaging the GCL. GCL shall only be handled and deployed using a stinger or spreader bar assembly meeting the requirements of ASTM D 5888 or as recommended by the GCL Manufacturer. Pushing, sliding, or dragging of GCL rolls is not permitted.
- J. Under no circumstances shall any construction or vehicular traffic be allowed to drive over exposed GCL. GCL showing evidence of trafficking shall be inspected to evaluate damage, if any. Any damaged GCL shall be repaired or replaced. A limited use of four-wheeled ATVs or other low ground pressure equipment may be allowed (having 6 psi or less contact pressure) by the GCL Installer during installation, but use shall be prohibited if excessive trafficking or any GCL damage is observed.
- K. GCL rolls shall be transported from the storage area to the working area in their original protective packaging. After packaging is carefully removed, GCL shall be unrolled and placed in such a manner as to minimize dragging of panels into position ("spotting").
- L. GCL Installer shall immediately provide permanent anchorage of the GCL to prevent panel movement during placement of covering materials (geomembrane and Common Fill). If bags are used for ballasting or temporary anchorage, they shall be filled with fine-grained sand or approved equal that has been approved for use. Any GCL exhibiting damage due to insufficient or improper temporary anchorage shall be repaired or replaced.
- M. GCL shall be installed so that it is in continuous contact with the underlying CCRs, without being tensioned, and with no wrinkles or folds. Bridging at the toe of slopes shall not be permitted. If bridging is observed, GCL Installer shall repair affected areas.

- N. GCL panel seams (edges) shall be oriented in a direction parallel to the line of maximum subgrade slope (i.e., down, not across the slope) and shall be placed in a manner that minimizes the number and length of field seams. In corners and odd-shaped geometric locations, the number of field seams shall be minimized and moved to locations outside the corners as appropriate.
- O. All GCL panel seams shall be shingled such that the "upstream" panel overlaps the "downstream" panel in order to minimize infiltration potential.

3.05 Seaming

- A. Lap joints shall be used to join GCL panels in the field. A minimum overlap of 18 inches shall be used for panel edges. Overlap areas shall be kept free of rocks, loose soil, or other debris. All GCL panels should be seamed as soon as possible after they are placed and prior to being covered with geomembrane.
- B. For the primary liner GCL, a continuous bead of accessory bentonite having a minimum width of 6 inches and applied at a minimum rate of one-quarter-pound per linear foot (1/4 lb/LF) of seam shall be placed in all seam overlap areas. This accessory bentonite shall if the GCL product has "supergroove" or other self-seaming enhancements.
- C. Seam overlap areas shall be left exposed after placing the accessory bentonite bead to verify that the overlap area and the accessory bentonite bead meet the requirements of this Section. Seam overlaps shall not be "closed" until verbal acceptance of the seam has been received.
- D. Completed GCL seams shall lay flat and be free of any rocks, loose soil, or other debris. Where wrinkles or folds do occur, the material shall be cut, overlapped, and a patch applied in accordance with Part 3.06 of this Section.

3.06 Repairs

- A. During installation, all GCL panels and seams for damage, defects, or non-compliance shall be inspected with the Contract Drawings and Specifications, and shall mark any such areas for repair. GCL Installer shall repair marked areas as soon as possible and prior to covering the GCL with geomembrane.
- B. Acceptable GCL repair methods include:
 - 1. Patching: For repair of surface defects, small tears, punctures, etc. Patches shall have a minimum size of 24 inches by 24 inches and extend at least 12 inches beyond the edge(s) of a defect. Accessory bentonite or bentonite mastic shall be placed around a defect prior to placement of a patch. Where practical, patches shall be placed beneath installed GCL panels. If placed on top of installed GCL panels, patches may be affixed in place using an adhesive. Care shall be taken to prevent fugitive bentonite from accumulating on the upper surface of the GCL and affecting geomembrane seaming operations.
- C. In cases where an object beneath the GCL is causing the GCL to protrude more than one-half-inch, the CQA Personnel may direct the GCL Installer to cut the GCL and remove the object prior to patching.

3.07 Acceptance and Covering

- A. No GCL shall be covered until it has been accepted.

- B. GCL Installer shall repair any areas identified as not being in accordance with the Contract Drawings and Specifications. Once all repairs are completed and accepted, GCL shall immediately be covered with geomembrane in accordance with the Contract Drawings and Specifications.
- C. If textured geomembrane is used to cover the GCL, a smooth temporary geosynthetic covering ("slip sheet") shall be used to protect the GCL from damage until the geomembrane is in its final position for seaming.

3.08 Warranties

- A. Any necessary guarantees or certifications from the GCL Manufacturer and GCL Installer shall be obtained and submitted them to the ENGINEER and OWNER prior to acceptance of installed GCL.
- B. Installer shall guarantee the integrity of the installed GCL for its intended use, from installation defects for a period of 2 years from the date of GCL installation. The Manufacturer of the GCL shall guarantee and from manufacturing defects for a period of 20 years from the date of GCL installation. Such written warranties shall provide for the total and complete repair and/or replacement of any defect or defective areas of GCL upon written notification and demonstration of the specific non-conformance of the GCL or installation with the Contract Drawings and Specifications. Such defects or non-conformance shall be repaired and/or replaced expeditiously.

Table 1
Required Properties of Geocomposite Clay Liner⁽¹⁾

Material Property	Test Method	Test Frequency [ft ² (m ²)] ⁽²⁾	Required Values
Bentonite Swell Index ⁽³⁾	ASTM D 5890	Once per 500,000 sf ²	24 ml/2g min.
Bentonite Fluid Loss ⁽³⁾	ASTM D 5891	Once per 500,000 sf ²	18 ml max.
Bentonite Mass/Area ⁽³⁾	ASTM D 5993	Once per 500,000 sf ²	0.75 lb./ft ² (3.6 kg/m ²) min
GCL Tensile Strength ⁽⁴⁾	ASTM D 6768	Once per 500,000 sf ²	50 lbs/in (53 N/cm) MARV
GCL Peel Strength ⁽⁴⁾	ASTM D 6496	Once per 500,000 sf ²	3.5 lbs/in (6.1 N/cm) min
GCL Hydraulic Conductivity ⁽⁵⁾	ASTM D 5887	Once per 500,000 sf ²	5 x 10-9 cm/sec max.
GCL Hydrated Internal Shear Strength ⁶	ASTM D 5321 ASTM D 6243	Once per 500,000 sf ²	500 psf (24 kPa) typ @ 200 psf

Notes:

- (1) The required properties specified herein are satisfied by the Bentomat DN as manufactured by CETCO Lining Technologies but may be revised by the ENGINEER to reflect new or revised test methods or to conform with improvements in state-of-the practice.
- (2) Number of specimens per test established in applicable test method unless otherwise noted.
- (3) Perform tests on as-received material before incorporation into finished GCL.
- (4) All tensile strength testing is performed in the machine direction using ASTM D6768. All peel strength testing is performed using ASTM D6496.
- (5) Permeability testing with deaired distilled/deionized water at 80 psi (551 kPa) cell pressure, 77 psi (531kPa) headwater pressure, and 75 psi (517kPa) tailwater pressure.
- (6) Peak value measures at 200 psf normal stress for a specimen hydrated for 48 hours.

-End of Section-

SECTION 02620

High Density Polyethylene (HDPE) Pipe and Fittings

Section 02620

High Density Polyethylene (HDPE) Pipe and Fittings

Part 1 General

1.01 Section Description

This specification includes but is not limited to high-density polyethylene (PE 3408) pressure pipe primarily intended for the transportation of water and sewage either buried or above grade.

1.02 Related Sections

- A. Drain Gravel/Coarse Aggregate - 02233
- B. Geotextiles - 02595
- C. Geocomposite Drainage Net - 02590

1.03 References

<u>Reference:</u>	<u>Title:</u>
AWWA C901	Polyethylene (PE) pressure Pipe & Tubing, ½ inch through 3 inch for water
AWWA C906	Polyethylene (PE) pressure Pipe & Fittings, 4 inch through 63 inch for water
ASTM D3035	Standard Spec for PE Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3261	Butt Heat Fusion PE Fittings for PE Pipe & Tubing
ASTM D3350	Standard Specification for PE Pipe & Fittings Materials
ASTM D1238	Melt Flow Index
ASTM D1505	Density of Plastics
ASTM D2837	Hydrostatic Design Basis
ASTM F714	Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
SF Std.#14	Plastic Piping Components & Related Materials
TR-33/2005	Plastic Pipe Institute - Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe

1.04 General

1.04.1 Use

High Density Polyethylene (HDPE) pipes/fittings shall be allowed for use as water, wastewater and reclaimed water pressure pipe where compatible with the specific conditions of the project.

1.04.2 Documentation

1. Documentation from the resin's manufacturer showing results of the following tests for resin identification:
 - a. Melt Flow Index ASTM D1238
2. Density ASTM D1505

1.04.3 Manufacturer

All HDPE pipe and fittings shall be from a single manufacturer, who is fully experienced, reputable, and qualified in the manufacture of the HDPE pipe to be furnished. The pipe shall be designed, constructed, and installed in accordance with the best practices and methods and shall comply with these Specifications. Qualified manufacturers shall be: PLEXCO Division of Chevron Chemical Company, DRISCOPIPE as manufactured by Phillips Products Co., Inc., SCLAIRPIPE as manufactured by DuPont of Canada or equal as approved by the Owner's Representative.

1.04.4 Warranty

The pipe MANUFACTURER shall provide a warranty against manufacturing defects of material and workmanship for a period of ten years after the final acceptance of the project by the OWNER. The MANUFACTURER shall replace at no expense to the OWNER any defective pipe/fitting material including labor within the warranty period.

Part 2 Products

2.01 Materials for Pipe Sizes Four-Inch Diameter and Larger

- A. Materials used for the manufacture of polyethylene pipe and fittings shall be made from a PE 3408 high density polyethylene resin compound meeting cell classification 345434C per ASTM D3350; and meeting Type III, Class C, Category 5, Grade P34 per ASTM D1238.
- B. High Density Polyethylene (HDPE) pipe shall comply with AWWA Specifications C906.
- C. If rework compounds are required, only those generated in the Manufacturer's own plant from resin compounds of the same class and type from the same raw material supplier shall be used.
- D. Dimensions and workmanship shall be as specified by ASTM F714. HDPE fittings and transitions shall meet ASTM D3261. HDPE pipe shall have a minimum density of 0.955 grams per cubic centimeter. All HDPE pipe and fittings shall have a Hydrostatic Design Basis (HDB) of 1,600 psi.

2.02 FITTINGS

- A. All molded fittings and fabricated fittings shall be fully pressure rated to match the pipe SDR pressure rating to which they are made. All fittings shall be molded or fabricated by the manufacturer. No Contractor fabricated fittings shall be used unless approved by the Engineer.
- B. The manufacturer of the HDPE pipe shall supply all HDPE fittings and accessories as well as any adapters and/or specials required to perform the work as shown on the Drawings and specified herein.

- C. All fittings shall be installed using butt-fused fittings, thermo-fused fittings/couplings, or flanged adapters and must be approved by the Engineer. NO size on size wet taps shall be permitted.

Part 3 Execution

3.01 Joining Method

- A. The pipe shall be joined with butt, heat fusion joints as outlined in ASTM D2657 and conform to the Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe, Technical Report TR-33/2005, published by the Plastic Pipe Institute (PPI). All joints shall be made in strict compliance with the manufacturer's recommendations. A factory qualified joining technician as designated by pipe manufacturer or experienced, trained technician shall perform all heat fusion joints in the presence of the Owner's Representative.
- B. Lengths of pipe shall be assembled into suitable installation lengths by the butt- fusion process. All pipes so joined shall be made from the same class and type of raw material made by the same raw material supplier. Pipe shall be furnished in standard laying lengths not to exceed 50 feet and no shorter than 20 feet.

3.02 Installation

- A. High Density Polyethylene (HDPE) Pipe shall be installed in accordance with the instruction of the manufacturer, as shown on the Drawings and as specified herein. A factory qualified joining technician as designated by the pipe manufacturer shall perform all heat fusion joints.
- B. HDPE shall be installed either by Open Trench Construction or direct placement on existing or regraded surface.
- C. Care shall be taken in loading, transporting and unloading to prevent damage to the pipe. Pipe or fitting shall not be dropped. All pipe or fitting shall be examined before installation, and no piece shall be installed which is found to be defective. Any damage to the pipe shall be repaired as directed by the Engineer. If any defective pipe is discovered after it has been installed, it shall be removed and replaced with a sound pipe in a satisfactory manner by the contractor, at his own expense.
- D. Under no circumstances shall the pipe or accessories be dropped into the trench or forced through a directional bore upon "pull-back".
- E. Care shall be taken during transportation of the pipe such that it will not be cut, kinked, or otherwise damaged.
- F. Ropes, fabric, or rubber protected slings and straps shall be used when handling pipes. Chains, cables, or hooks inserted into the pipe ends shall not be used. Two slings spread apart shall be used for lifting each length of pipe.
- G. Pipes shall be stored on level ground, preferably turf or sand, free of sharp objects, which could damage the pipe. Stacking of the polyethylene pipe shall be limited to a height that will not cause excessive deformation of the bottom layers of pipes under anticipated temperature conditions. Where necessary due to ground conditions, the pipe shall be stored on wooden sleepers, spaced suitably and of such width as not to allow deformation of the pipe at the point of contact with the sleeper or between supports.

- H. Pipe shall be stored on clean level ground to prevent undue scratching or gouging. The handling of the pipe shall be in such a manner that the pipe is not damaged by dragging it over sharp and cutting objects. The maximum allowable depth of cuts, scratches, or gouges on the exterior of the pipe is 5 percent of wall thickness. The interior pipe surface shall be free of cuts, gouges, or scratches.
- I. Pipe shall be laid to lines and grade shown on the Drawings with bedding and backfill as shown on the Drawings.
- J. When laying is not in progress, including lunchtime, the open ends of the pipe shall be closed by fabricated plugs, or by other approved means.
- K. Sections of pipe with cuts, scratches or gouges exceeding 5 percent of the pipe wall thickness shall be removed completely and the ends of the pipeline rejoined.
- L. The pipe shall be joined by the method of thermal butt fusion, as outlined in PART 3 – Execution, Section 3.01 Joining Method. All joints shall be made in strict compliance with the manufacturer's recommendations.
- M. All HDPE pipe must be at the temperature of the surrounding soil at the time of backfilling and compaction.
- N. If a defective pipe is discovered after it has been installed, it shall be removed and replaced with a sound pipe in a satisfactory manner at no additional cost to the Owner. All pipe and fittings shall be thoroughly cleaned before installation, shall be kept clean until they are used in the work and when laid, shall conform to the lines and grades required.

-End of Section-

SECTION 02708

Guardrail

SECTION 02708

Guardrail

Part 1 General

1.01 Description

- A. The WORK under this Section includes providing all labor, materials, tools, and equipment necessary for furnishing and installing guardrail as shown on the Drawings.

Part 2 Products

2.01 Materials

- A. Guardrail components and posts shall conform to the requirements of VDOT Standard Specifications Section 505.02. Guardrail and posts may be reused in accordance with VDOT Standard Specifications Section 505.03.
- B. Concrete for anchors shall meet the requirements of Section 03100 – Cast-in-Place Concrete.

Part 3 Execution

3.01 Construction

- A. Guardrail construction shall be in accordance with VDOT Standard Specifications Section 505.03, except that a trained guardrail installer shall not be required.

-End of Section-

SECTION 02936

Seeding

Section 02936

Seeding

Part 1 General

1.01 Description

- A. Supply all material, labor, equipment required for soil preparations and placement of seeding in location as directed by the Owner's Representative or as shown on the plans. This work shall include maintenance of established seeded areas until final acceptance. The Contractor shall be expected to provide and place all vegetative material necessary to complete the work.
- B. Apply lime, fertilizer, seed, and seed mulch to all areas disturbed by the work not receiving a specific surfacing.

1.02 Requirements of Regulatory Agencies

Pesticides, herbicides, and fungicides shall be used in accordance with the specifications of the prevailing Public Health Authority or Agricultural Extension Service.

1.03 Related Work

- A. Erosion and Sedimentation Control
- B. Vegetative Layer

1.04 Submittals

- A. Submit full and complete information on vegetative support layer material sampling and fertility testing results prior to amending vegetative material with lime and fertilizer.
- B. Submit to the Owner's Representative affidavits certifying that seed comply with the specifications.
- C. Submit Flexible Growth Medium or hydroseed procedure and application rates for approval by Owner's Representative.
- D. Submit full and complete written maintenance instructions for proper care and development of seeded areas to Owner prior to substantial completion.
- E. Submit material certification for seed mulch to the Owner's Representative.
- F. Submit recommendation from certified agriculturalist for type and rate of seeding and rate of lime application based on testing of vegetative support layer material.
- G. Seeding shall be limited to grasses and other shallow-rooted plants. Vegetation may not include trees, shrubs, or other plants with deep woody roots that may penetrate the geomembrane.

1.05 Product Handling

Deliver seed, lime, and fertilizer in new, clean, sealed containers.

1.06 Scheduling

- A. Schedule planting of permanent seeding areas for optimum germination as follows:
 - 1. Spring planting schedule is March 15th to June 15th.

2. Fall planting schedule is August 15th to October 15th.

B. Seeding dates other than listed above are to be approved by the Owner.

1.07 References

A. Virginia Erosion and Sediment Control Handbook (VESCH), Third Edition, 1992.

Part 2 Products

2.01 Fertilizer

The fertilizer shall be as indicated on the Drawings or by certified agronomist.

2.02 Seed

- A. Seed shall be brought on site unmixed unless the mixture is certified and stated on the package as to the quality and mixture. Mixing shall be done at the project site from the original unopened packages. Unless otherwise indicated from soil-specific analysis, seed mixtures and application rates shall be as shown on the Drawings. Sericea lespedeza is prohibited from use at this site. Kentucky 31 Tall Fescue, Red Top Grass, and Common Bermuda Grass are prohibited in Resource Protection Areas (RPA) and RPA mitigation Areas.
- B. Seed shall be certified as described in VESCH Standard and Specification 3.32. Seed quality shall be in accordance with VESCH Table 3.32E.

2.03 Agricultural Ground Dolomitic Limestone

- A. Agricultural ground dolomitic limestone shall conform to the standards of the Association of Official Agricultural Chemists, and must comply with all existing State and Federal regulations.
- B. The material must comply with the following gradation or recommendations of certified agronomist:

<u>Square Mesh Sieves</u>	<u>Percent Passing by Weight</u>
Pass # 10	100
Pass # 20	90
Pass # 100	40

- C. The minimum calcium carbonate equivalent shall be 90.
- D. The Owner reserves the right to draw such samples and perform such tests as he deems necessary to assure that these Specifications are met.

2.04 Seed Mulch

- A. Provide erosion control or hydromulch as required in areas to be seeded.
- B. Seed mulch shall be as indicated on the Drawings and in accordance with VESCH Standard and Specification 3.35.

Part 3 Execution

3.01 General

Sample vegetative support layer source material and obtain recommendation for seeding and soil amendments from a certified agronomist. Soil amendments and construction methods shall be those established as agronomically acceptable and feasible and which are approved by the Owner's Representative. Depending on the organic content of the proposed vegetative support soil, compost may be required to amend the vegetative support soil.

3.02 Seed Bed Preparation

- A. Surfaces to receive seed shall be prepared in accordance with VESCH Standard and Specification 3.29, Surface Roughening. The areas shall be scarified and made friable and receptive to seeding by approved methods, which will not disrupt the line and grade of the slope surface. In no event will seeding be permitted on hard or crusted soil surface.
- B. The finished surface shall be free from lumps or stones 6 inches or more in any dimension. Installation of grass areas may be done immediately after finish grading provided the seeding bed is in a good condition and not muddy or hard. If it is hard, loosen or roughen to a friable condition again. Loosening and roughening the soil shall be performed without damaging underlying geosynthetics.

3.03 Applying Lime, Fertilizer, Seed

- A. Seed areas within the areas disturbed by Contractor as directed by the Owner's Representative and Contract Drawings. After cleaning the seeding area of coarse material, maintain finish grades as shown on the Contract Drawings and spread fertilizer and lime uniformly over the areas using an approved mechanical spreader. The rate of application of fertilizer shall be as indicated on the Drawings or by soil test results.
- B. The lime application rates shall be as indicated on the Drawings but may be modified based on fertility test results. Lime shall be broadcasted to achieve a soil pH range between 6.0 and 7.0. Lime and fertilizer shall be incorporated into the soil by discing or other approved method as indicated on the Drawings.
- C. Do not undertake seeding in windy or unfavorable weather or when the ground is too wet to rake easily, frozen, or too dry.
- D. Apply seed uniformly with a broadcast spreader, drill, culti-packer seeder, or hydroseeder. Seeding depth should be 1/4 to 1/2 inch.
- E. To avoid poor germination rates as a result of seed damage during hydroseeding, if a machinery breakdown of 30 minutes to 2 hours occurs, 50 percent more seed shall be added to the tank, based on the proportion of slurry remaining in the tank. Beyond 2 hours, a full rate of new seed shall be provided and applied.

3.04 Replanting and Maintenance

- A. The Contractor shall be required to replant areas damaged by water, wind, fire, equipment or pedestrian traffic as necessary or when ordered by the Owner at no cost to the Owner.
- B. All areas and spots that do not show a prompt catch of vegetation shall be reseeded at 15-day intervals until a growth of grass is established.
- C. Contractor shall reseed as required to establish a minimum of 95 percent vegetation coverage within one year of initial planting. Contractor shall maintain seeded areas for a minimum of 1 year after vegetation is established and accepted by the Owner's

Representative. Maintenance, remedial seeding, fertilizer, and lime will be applied at no additional cost to the Owner.

3.05 Compaction

The Contractor shall keep all equipment and vehicular and pedestrian traffic off areas that have been seeded to prevent excessive compaction and damage to young plants. Where such compaction has occurred, the Contractor shall rework the soil to make a suitable seedbed; then reseed and reblanket such areas with the full amounts of the specified materials, at no extra expense to the Owner.

3.06 Mulching

- A. If seeding is done with hydromulching, then seeding mixture shall be increased 10 percent.
- B. Hydromulching of seeding areas shall have approved mulch applied at a rate as recommended by the manufacturer for tacking agent.
- C. Mulch applied in a separate application from seeding shall be applied within 48 hours after completion of the seeding operation.
- D. Other methods of mulching shall not be applied prior to approval by the Owner's Representative.
- E. Mulch rates shall be as indicated on the Drawings.

3.07 Maintenance of Grass Areas

- A. Water and reseed throughout the construction contract and/or acceptance by the Owner's Representative after seeding areas are substantially established turf areas.
- B. Install and maintain temporary protection fences, barriers, and signs where deemed necessary.

-End of Section-

SECTION 03000

Chain Link Fence and Gates

Section 03000

Chain Link Fence and Gates

Part 1 General

1.01 Summary

- A. This Section includes industrial/commercial chain link fence and gates specifications:
 - 1. Zinc-5% Aluminum alloy coated steel chain link fabric
 - 2. Galvanized steel framework and fittings
 - 3. Gates: swing and cantilever slide
 - 4. Barbed wire
 - 5. Installation
- B. Related Sections:
 - 1. Earthwork - 02200
 - 2. Seeding - 02936
 - 3. Cast-in-Place Concrete - 03100

1.02 References

- A. ASTM International (ASTM) A121 Specification for Metallic-Coated Carbon Steel Barbed Wire
- B. ASTM A392 Specification for Zinc-Coated Steel Chain-Link Fence Fabric
- C. ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
- D. ASTM A824 Specification for Metallic-Coated Steel Marcellled Tension Wire for Use With Chain Link
- E. ASTM F552 Standard Terminology Relating to Chain Link Fencing
- F. ASTM F567 Standard Practice for Installation of Chain Link Fence
- G. ASTM F626 Specification for Fence Fittings
- H. ASTM F900 Specification for Industrial and Commercial Swing Gates
- I. ASTM F1043 Specification for Strength and Protective Coatings of Steel Industrial Chain Link Fence Framework
- J. ASTM F1083 Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures

1.03 Submittals

- A. Certifications: The Contractor shall submit manufacturer's material certifications in compliance with the current ASTM specifications.
- B. Domestic certifications: The Contractor shall submit material certifications, Made in U.S.A., Buy American Act or Buy America when required.

1.04 Quality Assurance

- A. Fence contractor: Company with demonstrated successful experience installing similar projects and products in accordance with ASTM F567 having at least 5 years' experience.
- B. Tolerances: Current published edition of ASTM specifications tolerances apply. ASTM specification tolerances supersede any conflicting tolerance.

1.05 Delivery, Storage, and Handling

- A. Delivery: Deliver products to site.
- B. Storage: Store and protect products off the ground.

Part 2 Products

2.01 Chain Link Fabric

Steel Chain Link Fabric: Height or heights indicated on drawings, shall be 8 feet tall, with 2-inch mesh, Class 1(1.02 oz/ft²) zinc coated steel fabric per ASTM A392 hot dipped galvanized before weaving.

2.02 Round Steel Pipe Fence Framework

Round steel pipe and rail: Schedule 40 standard weight pipe, in accordance with ASTM F1083, 1.8 ounces per square foot (oz/ft²) (550 g/m²) hot dip galvanized zinc exterior and 1.8 oz/ft² (550 g/m²) hot dip galvanized zinc interior coating

Regular Grade: Minimum steel yield strength 30,000 pounds per square inch (psi) (205 MPa)

- 1. Line post: 2.375 outside diameter (OD), zinc coated, 3.65 pounds per foot (lb./ft.)
- 2. End, Corner, Pull post: 2.875 OD, zinc coated, 5.79 lb./ft.
- 3. Top, brace, bottom, and intermediate rails, 1.660-inch OD: zinc coated, 2.27 lb./ft.

2.03 Tension Wire

Metallic Coated Steel Marcellled Tension Wire: 7 gauge (0.177-inch) (4.50 millimeters) marcellled wire complying with ASTM A824, Type II Zinc-Coated, ASTM A817 Class 4 - 1.2 oz/ft².

2.04 Barbed Wire

Metallic Coated Steel Barbed Wire: Comply with ASTM A121, Design Number 12-4-5-14R, double 12.5 gauge 0.099-inch twisted strand wire, with 4 point 14 gauge 0.080-inch round barbs spaced 5 inches on center. Coating Type Z - Zinc-coated: Strand wire coating Type Z, Class 3, 0.80-oz/ft², barb coating 0.70-oz/ft².

2.05 Fittings

- A. Tension and Brace Bands: Galvanized pressed steel complying with ASTM F626, minimum steel thickness of 12 gauge (0.105-inch), minimum width of 0.75-inch and minimum zinc coating of 1.20 oz/ft². Secure bands with 0.3125-inch galvanized steel carriage bolts.
- B. Terminal Post Caps, Line Post Loop Tops, Rail, and Brace Ends, Boulevard Clamps, Rail Sleeves: In compliance to ASTM F626, pressed steel galvanized after fabrication having a minimum zinc coating of 1.20 oz/ft².
- C. Truss Rod Assembly: In compliance with ASTM F626, 0.375-inch diameter steel truss rod with a pressed steel tightener, minimum zinc coating of 1.2 oz/ft², assembly capable of withstanding a tension of 2,000 pounds.

- D. Tension Bars: In compliance with ASTM F626. Galvanized steel one-piece length 2 inches (50 millimeters) less than the fabric height. Minimum zinc coating 1.2 oz/ft². Bars shall have a minimum cross section of 0.1875-inch by 0.75-inch.
- E. Barbed Wire Arms: In compliance with ASTM F626, pressed steel galvanized after fabrication, minimum zinc coating of 1.20 oz/ft², capable of supporting a vertical 250 pound load. Type I – three strand 45 degree arm.

2.06 Tie Wire and Hog Rings

Tie Wire and Hog Rings: Galvanized minimum zinc coating 1.20 oz/ft², 9 gauge (0.148-inch) steel wire in compliance with ASTM F626.

2.07 Swing Gates

Swing Gates: Galvanized steel pipe welded fabrication in compliance with ASTM F900. Gate frame members 1.900-inch OD ASTM F 1083 schedule 40 galvanized steel pipe. Frame members spaced no greater than 8 feet apart vertically and horizontally. Welded joints protected by applying zinc-rich paint in accordance with ASTM Practice A780. Positive locking gate latch, pressed steel galvanized after fabrication. Galvanized malleable iron or heavy gauge pressed steel post and frame hinges. Provide lockable drop bar and gate holdbacks with double gates. Match gate fabric to that of the fence system. Gateposts per ASTM F1083 schedule 40 galvanized steel pipe. 4.000-inch OD. 9.11 lb./ft.

2.08 Concrete

Concrete for post footings shall have a 28-day compressive strength of 2,500 psi.

Part 3 Execution

3.01 Clearing Fence Line

Clearing: Surveying, clearing, grubbing, grading and removal of debris for the fence line or any required clear areas adjacent to the fence is included in Prepared Subgrade, and Cover Soil Layer contractor's contract. The contract drawings indicate the extent of the area to be cleared and grubbed.

3.02 Framework Installation

- A. Posts: Posts shall be set plumb in concrete footings in accordance with ASTM F567. Minimum footing depth, 36 inches. Minimum footing diameter shall be 16 inches. Top of concrete footing shall be crowned to shed water away from the post. Line posts installed at intervals not exceeding 10-foot on center.
- B. Top rail: Install 21-foot lengths of rail continuous thru the line post or barb arm loop top. Splice rail using top rail sleeves minimum 6 inches long. Rail shall be secured to the terminal post by a brace band and rail end. Bottom rail or intermediate rail shall be field cut and secured to the line posts using boulevard clamps or brace band with rail end.
- C. Terminal posts: End, corner, pull, and gate posts shall be braced and trussed. The horizontal brace rail and diagonal truss rod shall be installed in accordance with ASTM F567.
- D. Tension wire: Shall be installed 4 inches from the bottom of the fabric. Tension wire to be stretched taut, independently and prior to the fabric, between the terminal posts and secured to the terminal post using a brace band. Secure the tension wire to each line post with a tie wire.

3.03 Chain Link Fabric Installation

Chain Link Fabric: Install fabric to inside of the framework. Attach fabric to the terminal post by threading the tension bar through the fabric; secure the tension bar to the terminal post with tension bands and 0.3125-inch carriage bolts spaced no greater than 12 inches on center. Chain link fabric to be stretched taut free of sag. Fabric to be secured to the line post with tie wires spaced no greater than 12 inches on center and to horizontal rail spaced no greater than 18 inches on center. Secure fabric to the tension wire with hog rings spaced no greater than 18 inches on center. Tie wire shall be wrapped around the post or rail and attached to the fabric wire picket on each side by twisting the tie wire around the fabric wire picket two full turns. Excess wire shall be cut off and bent over to prevent injury. The installed fabric shall have a ground clearance on no more than 2 inches.

3.04 Barbed Wire Installation

Barbed Wire: Stretched taut between terminal posts and secured in the slots provided on the line post barb arms. Attach each strand of barbed wire to the terminal post using a brace band. Barb arm shall be Type I and direction inward.

3.05 Gate Installation

Swing Gates: Installation of swing gates and gateposts in compliance with ASTM F 567. Direction of swing shall be outward. Gates shall be plumb in the closed position having a bottom clearance of three inches, grade permitting. Hinge and latch offset opening space shall be no greater than three inches in the closed position. Double gate drop bar receivers shall be set in a concrete footing minimum six-inch diameter 24 inches deep. Gate leaf holdbacks shall be installed for all double gates.

3.06 Nuts and Bolts

Bolts: Carriage bolts used for fittings shall be installed with the head on the secure side of the fence. All bolts shall be peened over to prevent removal of the nut.

3.07 Clean Up

Clean Up: The area of the fence line shall be left neat and free of any debris caused by the installation of the fence.

-End of Section-

SECTION 03100

Cast-In-Place Concrete

Section 03100

Cast-In-Place Concrete

Part 1 General

1.01 Description of Work

Furnish and install miscellaneous cast-in-place concrete as shown and indicated on the Contract Drawings and as specified in this Section. This specification does not include structural concrete as in bridge or roadway uses.

1.02 Related References

- A. The latest edition of the publications listed below form a part of these Specifications:
1. American Concrete Institute (ACI) Publications:
 - 211.1 Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
 - 304 Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete
 - 305R Hot Weather Concreting
 - 306R Cold Weather Concreting
 2. United States Army Corps of Engineers Waterways Experiment Station Publication CRD-C-621: Handbook for Concrete and Cement, Specifications for Non-shrink Grout, Volume II
 3. American Association of State Highway and Transportation Officials Publication M 182 Burlap Cloth Made From Jute or Kenaf
 4. ASTM International (ASTM) Publications:
 - C 31 Making and Curing Concrete Test Specimens in the Field
 - C 33 Concrete Aggregates
 - C 39 Compressive Strength of Cylindrical Concrete Specimens
 - C 94 Ready-Mixed Concrete
 - C 143 Slump of Portland Cement Concrete
 - C 150 Portland Cement
 - C 172 Sampling Freshly Mixed Concrete
 - C 173 Air Content of Freshly Mixed Concrete by the Volumetric Method
 - C 231 Air Content of Freshly Mixed Concrete by the Pressure Method
 - C 260 Air-Entraining Admixtures for Concrete
 - C 494 Chemical Admixtures for Concrete
 - C 595 Blended Hydraulic Cements

1.03 Submittals

- A. Contractor shall be responsible for timely submittals to the Owner's Representative.
- B. The following submittals shall be provided for filling/plugging the Pond D outlet pipe:
1. Filling Plan. A plan detailing the Contractor's concrete mix equipment, setup, procedure, sequencing, plan for handling waste, method for communication, and

method for sealing and bulkheading upstream and downstream should be submitted to the Owner's Engineer prior to initiation of the filling operations. The watertight bulkhead must be capable of resisting the loads from the grout or concrete.

2. Concrete Mixtures. Documentation of adequate strength and flow from the planned mixture should be submitted to the Owner's Engineer prior to initiation of the filling operations.

Part 2 Products

2.01 Cement

Cement shall be standard Portland cement of American manufacture, conforming to ASTM C 150, Type I. Only one brand of commercial Portland cement shall be used in the exposed concrete of the structure. Cement reclaimed by cleaning bags or from leaking containers shall not be used.

2.02 Concrete Aggregates

- A. Fine aggregate shall be sand having clean, hard, durable, uncoated grains and free from deleterious substances and shall conform to ASTM C 33.
- B. Coarse aggregate shall be crushed stone having clean, hard, durable, uncoated particles conforming to ASTM C 33.

2.03 Water

Water used in mixing concrete shall be clean, potable, and free from deleterious amounts of acids, alkalis, or organic materials.

2.04 Admixtures

- A. Water reducing admixture shall conform to ASTM C 494, Type A.
- B. Water reducing, retarding admixture shall conform to ASTM C 494, Type D.
- C. Non-Corrosive, Non-Chloride Accelerator: The admixture shall conform to ASTM C 494, Type C.
- D. Air entraining admixture shall conform to ASTM C 260.
- E. High range water reducer (HRWR) shall conform to ASTM C494, Type F or G.
- F. Calcium Chloride: Calcium chloride or admixtures containing more than 0.1 percent chloride ions are not permitted.

Part 3 Execution

3.01 Concrete Quality

- A. Mix designs other than pipe filling concrete shall be proportioned in accordance with ACI 211.1. The proportioning shall be based on the requirements of a well-graded high density plastic and workable mix within the slump range and strengths required. The following class of concrete is required:

<u>Class of Concrete</u>	<u>Compressive Strength at 28 Days</u>	<u>Slump Range</u>
Virginia Department of Transportation A4	3,000 pounds per square inch	2 to 4 inches

1. Air Content: All concrete shall have an air content of 6.5 percent, +/- 1.5 percent.
 2. Water-Cement Ratio: All concrete shall have a maximum water-cement ratio of 0.45.
 3. Admixture Usage: All concrete shall contain a water reducing admixture or water reducing-retarding admixture, and an air entraining agent. All concrete placed at air temperatures below 50°F shall contain the specified non-corrosive non-chloride accelerator.
- B. Concrete for filling the outlet pipe shall be a non-shrink mix proportioned to provide a slump of about 6 to 7 inches and a compressive strength of 3,000 pounds per square inch at 28 days.

The mix shall have a water to cement ratio of 0.7:1 to 0.5:1. A grout fluidifier (ASTM C937) may be needed to promote flowability, reduce water requirements, reduce bleeding, reduce segregation, increase strength, and eliminate grout shrinkage during setting of the grout mix.

3.02 Plant Mixing

A. Proportioning Concrete

1. Proportions shall be in compliance with approved design mix for each class of concrete.
2. The mixing plant shall be provided with adequate equipment and facilities for accurate measurement and control of the quantities of material and water used in the concrete.
3. Concrete materials shall be measured by weight except that admixtures shall be measured by volume.

B. Batching

1. Ready-mixed concrete shall be mixed and delivered in accordance with requirements of ASTM C 94 and to the following:
 - a. A separate water metering device (not truck tank) shall be used for measuring water added to the original batch.
 - b. Use of wash water as a portion of the mixing water is not permitted. Wash water added to empty drums after discharging shall be dumped before a new batch is received.
 - c. Centrally mixed concrete shall be mixed for the length of time specified herein, not "shrink-mixed".
 - d. Mixing drums shall be watertight.
 - e. Concrete shall be discharged within one and a half hours from the time concrete was mixed, if centrally mixed, or from time the original water was added, if transit-mixed.
 - f. Furnish delivery ticket with each load of concrete delivered under these Specifications. Delivery ticket shall show clearly the class and strength of concrete, size of coarse aggregate, water per cubic yard, the slump

ordered, quantities of all admixtures, and the date and time of departure from the batching plant.

3.03 Conveying Equipment

- A. If concrete is to be transported in carts or buggies, the carts or buggies shall be equipped with pneumatic tires.
- B. Equipment for chuting or other methods of conveying concrete shall be of such size and design as to insure a practically continuous flow of concrete at delivery without segregation of materials.

3.04 Delivery and Protection of Materials

Deliver ready-mixed concrete in compliance with requirements set forth in ASTM C 94.

3.05 Severe-Weather Provisions

- A. Hot-Weather Concreting
 - 1. Provide adequate methods of lowering temperature of concrete ingredients so that the temperature of concrete when placed does not exceed 90°F.
 - 2. When the weather is such as to raise concrete temperature, as placed, consistently above 90°F, Pozzolite retarder shall be used.
 - 3. Subgrade and forms shall be wetted with water before placing of concrete. All excess water shall be removed before concrete is placed.
 - 4. Curing shall start as soon as practicable to prevent evaporation of water. Flat work shall be protected from dry winds, direct sun, and high temperatures.
- B. Cold-Weather Concreting
 - 1. Provide adequate equipment for heating concrete materials and protecting concrete during freezing or near-freezing weather. No frozen materials, or materials containing ice, shall be used.
 - 2. All concrete materials and all reinforcement, forms, fillers and ground with which concrete is to come into contact shall be free from frost.
 - 3. Whenever the temperature of the surrounding air is below 40°F and falling, all concrete placed in the forms shall have a temperature of between 70 and 80°F, and adequate means shall be provided for maintaining a temperature of not less than 70°F for 3 days, or 50°F for 5 days, or for as much more time as is necessary to insure proper curing of the concrete. If high early strength concrete is used, the requirement for maintenance of 50°F can be reduced to 3 days.
 - 4. Use only the specified non-chloride accelerator. Calcium chloride or admixtures containing more than 0.1 percent chloride ions are not permitted.
 - 5. Housing, covering, or other protection used in connection with curing shall remain in place and intact at least 24 hours after the artificial heat is discontinued.

3.06 Placing

- A. Deposit concrete as nearly as practicable in its final position to avoid segregation due to re-handling or flowing. Do not deposit concrete on work that has partially hardened or been contaminated by foreign material, and do not use re-tempered concrete.

- B. Concrete shall not be dropped more than 4 feet. For greater distances of drop, concrete shall be handled with metal chutes or tremie pipes.
- C. Concrete shall be placed in layers not over 12 inches deep and each layer shall be compacted with the aid of mechanical internal-vibrating equipment supplemented by hand spading. Vibrators shall in no case be used to transport concrete. Use of form vibrators will not be permitted. Internal vibrators shall maintain a speed of not less than 5,000 impulses per minute when submerged in the concrete. At least one spare vibrator shall be maintained as a relief. Provide backup power source. Duration of vibrator use shall be limited to that necessary to produce satisfactory consolidation without causing objectionable segregation. Vibrator shall not be lowered into courses that have begun to set. Apply vibrator at uniformly spaced points not further apart than the visible effectiveness of the machine.
- D. Foundations shall be Seced and the concrete deposited in the dry.
- E. Outlet Pipe Filling
 - 1. Remaining outlet pipe shall be filled after Phase 3 grading has been established but prior to placement of CCM.
 - 2. Prior to filling the pipe shall be inspected for the existence of voids, protrusions, or obstructions. The Contractor shall use a camera to complete a video inspection of the outlet pipe.
 - 3. The existing conduit surfaces against which grout will be placed shall be free of roots, sediments, mineral deposits, loose or defective concrete, and other foreign materials. Any sediment or debris should be removed.
 - 4. The downstream end of the pipe shall be sealed with a watertight bulkhead capable of resisting the loads from the grout or concrete.
 - 5. Grouting equipment should be capable of continuously pumping grout at any pressure up to 50 pounds per square inch. Injection pipes for concrete should be about 5 inches in diameter.
 - 6. Concrete shall be placed such that air will not be trapped in the pipe. Tremie or alternate method should be used to distribute the grout in the outlet pipe.
 - 7. After the concrete has set, the bulkhead(s) shall be removed, as appropriate.

-End of Section-

SECTION 03301

Sanitary Utility Sewerage Force Main Testing

Section 03301

Sanitary Utility Sewerage Force Main Testing

Part 1 General

1.01 Summary

- A. Contractor shall furnish all supervision, labor, products, equipment, and tools, including all necessary and incidental items as detailed or required, to test sanitary sewerage force main in accordance with the Drawings, Specifications, and project Construction Quality Assurance (CQA) Plan.
- B. If differences exist between the drawings and specifications, the stricter shall apply.

1.02 Reference Standards

- A. American Water Works Association (AWWA), latest revision:
- B. AWWA C605 - Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented PVC Pressure Pipe and Fittings.

1.03 Submittals

- A. Contractor shall be responsible for timely submittals to the Owner's Representative and Owner.
- B. Submit following items prior to start of testing:
 - 1. Testing procedures.
 - 2. List of test equipment.
 - 3. Testing sequence schedule.
 - 4. Provisions for disposal of flushing and test water.
 - 5. Certification of test gage calibration.
- C. Test and Evaluation Reports: Indicate results of piping tests.

Part 2 Products

2.01 Hydrostatic Testing

- A. Equipment:
 - 1. Hydro pump.
 - 2. Pressure hose.
 - 3. Water meter.
 - 4. Test connections.
 - 5. Pressure relief valve.
 - 6. Pressure Gage: Calibrated to 0.1 psi (0.69 kPa).

Part 3 Execution

3.01 Examination

- A. Verify that piping are ready for testing.
- B. Verify that trenches are backfilled.
- C. Verify that pressure piping thrust restraint system is installed.

3.02 Preparation

- A. Valves:
 - 1. Verify isolation valves are closed.

3.03 Field Quality Control

- A. Testing of Pressure Piping:
 - 1. Test system according to AWWA C605 and following:
 - a. Hydrostatically test each portion of pressure piping, including valved section, at 1.5 times working pressure of piping or 150 psi, whichever is greater, based on elevation of lowest point in piping corrected to elevation of test gage.
 - b. Conduct hydrostatic testing for at least two hours.
 - c. Slowly fill with water portion of piping to be tested, expelling air from piping at high points.
 - d. Install corporation cocks at high points.
 - e. Close air vents and corporation cocks after air is expelled.
 - f. Raise pressure to specified test pressure.
 - g. Remove and renew cracked pipes, joints, fittings, and valves that show visible leakage.
 - h. Retest.
 - i. Correct visible deficiencies and continue testing at same test pressure for additional two hours to determine leakage rate.
 - j. Maintain pressure within plus or minus 5.0 psi (34.4 kPa) of test pressure.
 - k. Leakage is defined as quantity of water supplied to piping necessary to maintain test pressure during period of testing.
 - l. Compute maximum allowable leakage using following formula:
 - i. $L = [SD \times \sqrt{P}]/C$.
 - ii. L = testing allowance, gph (L/h).
 - iii. S = length of pipe tested, feet (m).
 - iv. D = nominal diameter of pipe, inches (mm).
 - v. P = average test pressure during hydrostatic testing, psig (kPa).
 - vi. C = 148,000 (794,797).

- vii. If pipe undergoing testing contains sections of various diameters, calculate allowable leakage from sum of computed leakage for each pipe size.
2. If testing of piping indicates leakage greater than that allowed, locate source of leakage, make corrections, and retest until leakage is within acceptable limits.
3. Correct visible leaks regardless of quantity of leakage.

-End of Section-

SECTION 03334

Sanitary Utility Sewerage Force Mains

Section 03334

Sanitary Utility Sewerage Force Mains

Part 1 General

1.01 Summary

- A. Contractor shall furnish all supervision, labor, products, equipment, and tools, including all necessary and incidental items as detailed or required, to install sanitary sewerage force main in accordance with the Drawings, Specifications, and project Construction Quality Assurance (CQA) Plan.
- B. If differences exist between the drawings and specifications, the stricter shall apply.

1.02 Reference Standards

- A. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. AASHTO T180 - Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
- B. American Water Works Association, latest revisions:
 - 1. American Water Works Association (AWWA) C104 - Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
 - 2. AWWA C110 - Ductile-Iron and Gray-Iron Fittings.
 - 3. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - 4. AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. through 12 In. (100 mm through 300 mm), for Water Transmission and Distribution.
 - 5. AWWA C605 - Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented PVC Pressure Pipe and Fittings.
- C. ASTM International (ASTM):
 - 1. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³).
 - 2. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³).
 - 3. ASTM D2241 - Standard Specification for PVC Pressure-Rated Pipe (SDR Series).
 - 4. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
- D. Ductile Iron Pipe Research Association:
 - 1. Thrust Restraint Design for Ductile Iron Pipe.

1.03 Coordination

- A. Coordinate Work of this Section with Owner's Representative and Prince William County Service Authority.

1.04 Submittals

- A. Contractor shall be responsible for timely submittals to the Owner's Representative.
- B. The following submittals shall be provided:
 - 1. Product Data: Submit manufacturer information indicating pipe material used, pipe accessories, valves, restrained joint details, and materials.
 - 2. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
 - 3. Manufacturer Instructions: Indicate special procedures and tools required to install specified products.
 - 4. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.
 - 5. Qualifications Statements:
 - a. Submit qualifications for manufacturer, installer, and licensed professional.
 - b. Submit manufacturer's approval of installer.

1.05 Closeout Submittals

- A. Project Record Documents: Record invert elevations and actual location of pipe runs and connections.
- B. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.06 Construction Quality Assurance

- A. Perform Work according to latest revision of American National Standards Institute (ANSI) /AWWA standards.
- B. Maintain 1 copy of each standard affecting Work of this Section on Site.

1.07 Delivery, Storage, and Handling

- A. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.
- B. Storage:
 - 1. Store materials according to manufacturer instructions.
 - 2. Do not place materials on private property without written permission of property owner.
 - 3. Do not stack pipe higher than recommended by pipe manufacturer.
- C. Protection:
 - 1. Protect all materials from vandalism and theft.
 - 2. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
 - 3. Store gaskets for mechanical and push-on joints in cool and dry location, out of direct sunlight, and not in contact with petroleum products.

4. Provide additional protection according to manufacturer instructions.
5. Provide freeze protection during cold weather.

1.08 Existing Conditions

A. Field Measurements:

1. Verify field measurements prior to fabrication.
2. Indicate field measurements on Shop Drawings.

B. Utilities:

1. Call Virginia 811 "one call" (800-552-7001) prior to earthwork activities.
2. Field verify existing utilities.
3. Notify Owner's Representative of any conflicts.

Part 2 Products

2.01 Force Main

A. PVC Pressure Sewer Pipe and Fittings, 12-Inch (300-mm) Nominal Size and Smaller:

1. Comply with AWWA C900.
2. Class 235.
3. Joints: Push On.

B. Ductile-Iron Fittings:

1. Comply with AWWA C110.
2. Pressure Rating: 250 psig.
3. Cement mortar lined and outside coated.
4. Joints:
 - i. Comply with AWWA C111.
 - ii. Type: Mechanical.
5. Rubber Gaskets, Lubricants, Glands, Bolts, and Nuts: Comply with AWWA C111.

C. Plug Valves:

1. Comply with AWWA C517.
2. Pressure Rating: 250 psig.
3. Inside and outside epoxy coated.
4. Joints:
 - i. Comply with AWWA C111.
 - ii. Type: Mechanical.
5. Rubber Gaskets, Lubricants, Glands, Bolts, and Nuts: Comply with AWWA C111.

- D. Restraint: Thrust blocks or retainer glands per Drawings.
 - 1. EBAA Iron Series 1500 or approved equal for push on joints.
 - 2. EBAA Iron Series 1100 Megalug or approved equal for plain end connections to mechanical joint ductile iron fittings.

2.02 Bedding and Cover

- A. Bedding: Fill Type as specified in Drawings.
- B. Cover: Fill Type as specified in Drawings.
- C. Soil Backfill from above Pipe to Finish Grade: Soil Type as specified in Drawings.
- D. Subsoil: No rocks more than six inches (150 mm) in diameter, frozen earth, or foreign matter.

2.03 Mixes

- A. Concrete: As specified in Drawings and Section 03100.

Part 3 Execution

3.01 Examination

- A. Contractor is responsible for site safety in accordance with Section 01000.
- B. Verify that trench cut is ready to receive Work and complies with Occupational Safety and Health Administration requirements.
- C. Verify that excavations, dimensions, and elevations are as indicated on Drawings.

3.02 Preparation

- A. Correct over-excavation with coarse aggregate.
- B. Remove large stones or other hard matter capable of damaging pipe or of impeding consistent backfilling or compaction.

3.03 Installation

- A. Bedding:
 - 1. Excavate pipe trench as specified in Drawings.
 - 2. Install piping level or with continuous positive slope to existing air release vault.
 - 3. Place bedding material at trench bottom.
 - 4. Level materials in continuous layers not exceeding 6 inches in depth.
 - 5. Maintain optimum moisture content of bedding material to attain required compaction density.
- B. Piping:
 - 1. Install pipe, fittings, and accessories as indicated on Drawings.
 - 2. Route piping in straight line.
 - 3. Install bedding at sides and over top of pipe as indicated on Drawings.
 - 4. Backfilling and Compacting:

- a. As specified in Drawings.
 - b. Do not displace or damage pipe while compacting.
- 5. Installation Standards: Install Work according to ANSI/AWWA standards.
- C. Thrust Restraints:
 - 1. Provide pressure pipeline with restrained joints or concrete thrust blocking at bends, tees, and changes in direction.
 - 2. Construct concrete thrust blocking as indicated on Drawings.

3.04 Field Quality Control

- A. Inspections: Request inspection by Owner's Representative prior to placing bedding.
- B. Testing:
 - 1. If tests indicate that Work does not meet specified requirements, remove Work, replace, and retest.
 - 2. Pipe Testing:
 - a. Pressure Test: As specified in Section 330130.13 - Sanitary Utility Sewerage Forcemain Testing.

3.05 Protection

- A. Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.

-End of Section-

SECTION 03346

Corrugated Plastic Pipe

SECTION 03346

Corrugated Plastic Pipe

Part 1 General

1.01 Description of Work

The Contractor shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the work of furnishing, placing and compacting the stone as shown, specified or required. Contractor shall implement and supervise all work.

1.02 Related Sections

- A. Drain Gravel /Coarse Aggregate
- B. Nonwoven Filter Geotextile
- C. Geocomposite Drainage Net

1.03 Submittals

The Contractor shall submit manufacturer's technical data, including cut sheets, standard specifications, and manufacturing information for all perforated and solid pipe and fittings.

1.04 Quality Assurance

- A. Pipe installation shall be performed by skilled workers. Each pipe laying crew shall have a pipe laying foreman.
- B. Pipe shall be accurately installed to the lines and grades shown on the Construction Drawings, or as approved by the Owner's Representative, so that inverts are smooth.
- C. Deflections in horizontal alignment at joints are not permitted without the written consent of the Owner's Representative. If so approved, the deflections shall not exceed one-half the manufacturer's recommendation.
- D. The Owner's Representative shall be notified in advance whenever an existing pipeline location conflicts with the proposed locations of the Work.
- E. Pipe and fittings of the same type shall be the products of a single manufacturer.
- F. All piping shall be of the type and size as shown on the Construction Drawings and described in herein.

1.05 Delivery, Storage, and Handling

- A. All pipes and fittings shall be carefully handled when loading and unloading. Lift by hoists or lower on skidways in a manner to avoid shock.
- B. Where required, due to weight of material and for the safety and protection of workmen, materials, equipment, property, and the work, use derricks, ropes, or other suitable equipment for lowering pipe into trenches. Take particular care to avoid damaging the pipe.
- C. Pipe and fittings shall be protected against the damaging ultraviolet rays of the sun when stored for any period. Such protection shall consist of canvas covering, or other material as recommended by the manufacturer. Plastic sheets shall not be used which may allow excessive temperatures to develop where pipe is stored. All pipe which has been distorted or otherwise negatively affected by high temperatures shall be rejected, regardless of the

pipe's appearance after return to ambient temperatures. Rejected pipe shall be marked by the QC Team and removed from the site of the work at the sole expense the Contractor.

- D. The manufacturer's recommended procedures for pipe stacking shall be followed. When pipe is stacked for storage, the heaviest series of pipe shall be placed at the bottom.
- E. Pipe and fittings shall be protected from damage by sharp objects through all phases of work.
- F. If any defective pipe is discovered after being laid or placed, removal and replacement with a sound pipe will be required without cost to the Owner.

Part 2 Products

2.01 Pipe and Fittings

- A. The HDPE Corrugated Plastic Pipe (CPP) shall have a nominal inside diameter as shown and shall have external corrugations with an integrally formed smooth interior surface (Advanced Drainage Systems N-12 Pipe or approved equivalent).
- B. The pipe shall meet the requirements of AASHTO designations M-252 Type S (4 to 10 inch pipe) or M-294 (12 to 60 inch) Type S.
- C. The CPP pipe and any HDPE pipe fittings shall be composed of polyethylene compounds meeting the requirements of ASTM D 1248 for Type III, Category 4 or 5, Grade P33 or P34 polyethylene. Clean reworked material may be used.
- D. The minimum parallel plate pipe stiffness shall be 34 psi as measured by ASTM D 2412.
- E. The pipe and fittings shall be free of foreign inclusions and visible defects. The pipe perforations shall be as indicated on the Drawings. The ends shall be cut squarely so as not to adversely affect joining.
- F. Joints shall be of the bell and spigot type. Sections shall have water-tight joints.

Part 3 Execution

3.01 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Section 02200 Earthwork.

3.02 Piping Installation

- A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Solid pipe shall be butt fusion welded per manufacturer's written instructions. Perforated pipe shall be installed with perforations down.
- B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.
- C. Join perforated PE pipe and fittings with couplings according to ASTM D 3212 with loose banded, coupled, or push-on joints.

3.03 Cleaning

Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

-End of Section-

SECTION 03410

Precast Concrete Pipe

SECTION 03410

Precast Concrete Pipe

Part 1 General

1.01 Related Sections

Section 02200 Earthwork

Section 02233 Drain Gravel/Coarse Aggregate

1.02 References

Where applicable, the latest editions of the following standards shall form a part of this specification to the extent referenced. The publications are referenced to in the text of this guide specification by the basic designation only.

American Concrete Pipe Association (ACPA)

ACPA Concrete Pipe Handbook

ACPA Design Manual

ASTM International (ASTM)

ASTM C14 Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe

ASTM C76 Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

National Precast Concrete Association (NCPA)

NCPA QC Manual Quality Control Manual for Precast Concrete Plants

1.03 General Requirements

Precast concrete units shall be designed and fabricated by an experienced and acceptable precast concrete manufacturer. The manufacturer shall have been regularly and continuously engaged in the manufacture of precast concrete units similar to that indicated in the project specifications or drawings for at least 10 years with annual sales of more than \$40 million. In addition, the manufacturer shall employ a professional engineer registered in the state where the product is to be installed.

1.04 Submittals

The following items shall be submitted unless specified otherwise herein.

A. Preconstruction Submittals

1. Upon request by the customer, submit quality control procedures established by the precast manufacturer's Quality Control Manual

B. Drawings

1. The drawings for precast concrete units shall be furnished by the precast concrete producer for approval. These drawings shall show the design loads and standards have been met. Installation and construction information shall be included on shop drawings upon request. Details of steel reinforcing size and placement shall be submitted if a professional engineering stamp and calculations are required by the

customer. It is the responsibility of the project's engineer-of-record to verify that the design assumptions are suitable for the proposed application.

C. Precast Concrete Unit Data

1. Accessory Items

- a. For items including, but not limited to sealants, gaskets, pipe entry connectors, steps, racks, and other items installed before or after delivery, the precast concrete producer shall include proper installation instructions and relevant product data upon request.

1.05 Delivery, Storage, and Handling

A. Handling

1. Precast concrete units shall be handled and transported in a manner to minimize damage. Lifting devices or holes shall be consistent with industry standards. Lifting shall be accomplished with methods or devices intended for this purpose as indicated on the shop drawings. Upon request, the precast concrete producer shall provide documentation on acceptable handling methods for the product.

B. Storage

1. Precast concrete units shall be stored in a manner that will minimize potential damage.

C. Delivery

1. Precast concrete units shall be delivered to the site in accordance with the delivery schedule. Upon delivery to the jobsite, all precast concrete units shall be inspected by the customer's agent for quality and final acceptance.

D. Final Acceptance

1. Upon final acceptance, the customer's agent acknowledges and understands the appropriate methods for handling the accepted precast concrete unit(s). Upon acceptance by the customer or customer's agent, the precast concrete manufacturer is not responsible for replacing damaged product resulting from improper handling practices on the job site.

Part 2 Products

2.01 Materials

Except as otherwise specified, material shall conform to the following section.

A. Materials

Cement	Standard Specification for Admixtures to Inhibit ASTM C 150 (Type I, II, III, or V) ASTM C 595 (for Blended Cements)
Silica Fume	ASTM C 1240
Fly Ash and Pozzolans	ASTM C 618

Ground Granulated Blast-Furnace Slag	ASTM C 989
Water	ASTM C 1602 (the use of reclaimed/recycled water shall be permitted)
Aggregates	ASTM C 33 (and aggregate specifications)
Air Entraining Admixtures	ASTM C 260
Accelerating, Retarding, Water Reducing Admixtures	ASTM C 494
Corrosion Inhibitors	ASTM C 1582
Reinforcing Bars	ASTM A 615 or ASTM A 706
Plain, Welded Wire Reinforcement	ASTM A 185
Deformed, Welded Wire Reinforcement	ASTM A 497
Epoxy Coated Reinforcing Bars	ASTM A 775
Epoxy Coated Welded Wire Reinforcement	ASTM A 884
Hot-Dipped Galvanizing for Inserts	ASTM A 152
Rubber Gaskets for Circular Pipe	ASTM C 443
External Sealing Bands for Pipe	ASTM C 877
Preformed Flexible Joint Sealants for Concrete Pipe, Manholes, and Manufactured Box Sections	ASTM C 990
Elastomeric Joint Sealants	ASTM C 920
Pipe Entry Connectors	ASTM C 923, ASTM C 1478
Nonshrink Grout	ASTM C 1107

2.02 Manufacture

Manufacture shall conform to the producer's acceptable quality control manual

A. Forms

1. Forms for manufacturing precast concrete units shall be of the type and design consistent with industry standards and practices. They should be capable of consistently providing uniform products and dimensions. Forms shall be constructed so that the forces and vibrations to which the forms will be subjected cause no damage to the precast concrete unit.
2. Forms shall be cleaned of concrete build-up after each use.
3. Form release agents shall be applied according to the manufacturer's recommendations and shall not be allowed to build up on the form casting surface.

B. Reinforcement

1. Cages of reinforcement shall be fabricated by tying the bars, wires or welded wire reinforcement. The tolerances for concrete cover shall be 3/8 in. or as specified in the design. Welding shall be allowed only for ASTM A 706 rebar.
2. Positive means shall be taken to assure that the reinforcement does not move significantly during the casting operations.

C. Concrete

1. Concrete Mixing

- a. Mixing operations shall produce batch-to-batch uniformity of strength, consistency, and appearance.
- b. Batching weight and volume measurement devices shall be annually calibrated by an independent testing laboratory or more frequently if batching irregularities or concrete inconsistencies are observed.

2. Concrete placing

- a. Concrete shall be placed in a manner in which it flows and consolidates without segregation or air entrapment. The freefall of concrete shall be kept to a minimum.
- b. Cold Weather Concreting
 - 1) Recommendations for cold weather concreting are given in detail in ACI 306 R. Adequate equipment shall be provided for heating concrete materials and protecting concrete during freezing or near-freezing temperatures. All concrete materials, reinforcement, and forms shall be free from frost. In cold weather, the temperature of the concrete at the time of placement shall not be below 45 degrees F. Concrete that freezes before it reaches a compressive strength of 500 psi shall be discarded.
- c. Hot Weather Concreting
 - 1) Recommendations for hot weather concreting are given in detail in ACI 305 R. During hot weather excessive concrete temperatures and water evaporation shall be minimized. The temperature of concrete at the time of placing shall not exceed 95 degrees F.

3. Concrete Curing

- a. Curing operations shall commence immediately following the initial set of the concrete and completion of surface finishing.
- b. Curing by moisture retention
 - 1) Precast products shall be protected from drafts and wind to prevent plastic shrinkage cracking.
 - 2) Moisture shall be prevented from excessively evaporating from exposed surfaces until adequate strength for stripping the precast concrete unit from the form is reached.

c. Curing with Heat and Moisture

- 1) Concrete shall not be subjected to steam or hot air until after the concrete has attained its initial set. If hot air is used, precautions shall be taken to prevent moisture loss from the concrete. The temperature of the concrete shall not be permitted to exceed 150 degrees F. The temperature gain shall not exceed 40 degrees F per hour.

4. Surface Finish

- a. The surface finish shall be as specified on the contract documents and/or approved shop drawings.

5. Stripping Precast Concrete Units from Forms

Precast concrete units shall not be removed from the forms until the concrete reaches the compressive strength for stripping required by design. Stripping strengths shall be routinely measured to ensure product has attained sufficient strength for safe handling.

6. Patching and Repair

a. Repairing Minor Defects

- 1) Defects that will not impair the functional use or expected life of the precast concrete unit may be repaired by any method that does not impair the product.

b. Repairing Honeycombed Areas

- 1) When honeycombed areas are to be repaired, all loose material shall be removed and the areas cut back into essentially horizontal or vertical planes to a depth at which coarse aggregate particles break under chipping rather than being dislodged. Proprietary repair materials shall be used in accordance with the manufacturer's instructions. Otherwise, the area shall be saturated with water. Immediately prior to repair, the area should be damp, but free of excess water. A cement-sand grout or an approved bonding agent shall be applied to the chipped surfaces, followed immediately by consolidating an appropriate repair material into the cavity.

c. Repairing Major Defects

- 1) Defects in precast concrete products which impair the functional use or the expected life of products shall be evaluated by qualified personnel to determine if repairs are feasible and, if so, to establish the repair procedure.

7. Shipping Precast Concrete Units

- a. Precast concrete units shall not be shipped until they have reached at least 70% of their specified 28-day design strength, unless damage will not result, impairing the performance of the product.

Part 3 Execution

3.01 Excavating

- A. If unforeseen facilities or obstructions are encountered, stop excavation operations immediately. Expose the obstruction with wood handled digging tools and investigate them with caution. If there is any doubt as to the type of obstruction exposed, request positive identification from those suspected of owning the facility and then proceed as circumstances dictate.
- B. Inspect excavations after every rainstorm or other hazard-increasing occurrence, and increase the protection against slides and cave-ins, if necessary.
- C. In dewatering excavations, make certain that the discharge is carried to a suitable runoff point. Also verify that the design accounts for the level of groundwater encountered.
- D. Excavation size shall be large enough to allow access around the structure after it is installed.

3.02 Shoring

- A. Shoring for construction shall be in accordance with all federal, state, and local regulations.

3.03 Installation

- A. Site Access
 - 1. The general contractor shall be responsible for providing adequate access to the site to facilitate hauling, storage, and proper handling of the precast concrete units.
- B. Subgrade Bedding Materials and compaction
 - 1. The installation contractor shall be responsible for ensuring that the subgrade is compacted to 95% of ASTM D698 density. The subgrade shall be a minimum of 6" in depth. A granular material shall be used to create a level surface for placing the precast concrete unit.
- C. Installation
 - 1. Precast concrete units shall be installed: to the lines and grades shown on the contract documents or otherwise specified; be lifted by suitable lifting devices at points provided by the precast concrete producer; in accordance with applicable industry standards. Upon request, the precast concrete producer shall provide installation instructions
 - 2. Field modifications to the product shall relieve the precast producer of liability and warranty regardless if such modifications result in the failure of the precast concrete unit.

3.04 Backfilling and Restoration

- A. Do the backfilling as soon as possible after the structure has been placed.
- B. Backfill material shall be granular and free from large stones, rocks, and pavement. Expansive soil material shall not be used as backfill around the structure.
- C. Backfilling shall be achieved by lifts (layers) to the required compaction.

- D. Follow up inspections for settlements are required. Should settlement occur, the contractor shall be responsible for all necessary repairs.

3.05 Field Quality Control

A. Job Site Tests

When leak resistance testing is required for a precast concrete structure, one of the following methods may be followed.

1. Vacuum Testing
 - a. Prior to backfill, vacuum test system according to ASTM C 1244 for manholes and ASTM C 1227 for septic tanks.
2. Hydrostatic Testing
 - a. First Backfill the structure, then fill to the normal water level, let stand for 24 hours. Refill to the original water line and measure the water level change over a 24 hour period. Leak shall not exceed 5% of volume.

B. Inspection

1. Final field elevations and compaction properties shall be verified and documented.

-End of Section-

SECTION 03500

Uniform Section (US) Fabric Formed Concrete Erosion Control Lining System

Section 03500

Uniform Section (US) Fabric Formed Concrete Erosion Control Lining System

Part 1 General

1.01 Scope of Work

Contractor shall furnish all labor, materials, equipment, and incidentals required and perform all operations in connection with the installation of the fabric formed concrete erosion control lining systems in accordance with these specifications, and the Project Construction Quality Assurance (CQA) Plan. The work shall consist of installing an unreinforced concrete lining by positioning specially woven, dual wall synthetic fabric forms on the surface to be protected and filling them with a pumpable fine aggregate concrete (structural grout) in such a manner as to form a stable lining of required thickness and configuration.

1.02 Referenced Documents

A. American Society for Testing and Materials (ASTM)

1. ASTM C 31 Standard Practice for Making and Curing Concrete Test Specimens in the Field
2. ASTM C 33 Standard Specification for Concrete Aggregates
3. ASTM C 39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
4. ASTM C 150 Standard Specification for Portland Cement
5. ASTM C 494 Standard Specification for Chemical Admixtures for Concrete
6. ASTM C 260 Standard Specification for Air-Entraining Admixtures for Concrete
7. ASTM C 618 Standard Specification for Coal Fly Ash and Calcined Natural Pozzolan for Use in Concrete
8. ASTM D 4354 Practice for Sampling of Geotextiles for Testing
9. ASTM D 4491 Standard Test Methods for Water Permeability of Geotextiles by Permittivity
10. ASTM D 4595 Test Method for Tensile Properties of Geotextiles by the Wide Width Strip Method
11. ASTM D 4533 Standard Test Method for Trapezoidal Tearing Strength of Geotextiles
12. ASTM D 4632 Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)
13. ASTM D 4751 Test Method for Determining Apparent Opening Size for a Geotextile
14. ASTM D 4759 Practice for Determining the Specification Conformance of Geotextiles
15. ASTM D 4873 Standard Guide for Identification, Storage, and Handling of Geotextiles

16. ASTM D 4884 Test Method for seam Strength of Sewn Geotextiles
17. ASTM D 5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
18. ASTM D 5261 Test Method for Measuring Mass per Unit Area of Geotextiles
19. ASTM D 6449 Standard Test Method for Flow of Fine Aggregate Concrete for Fabric Formed Concrete (Flow Cone Method)

1.03 Submittal

- A. The Contractor shall furnish records of past successful experience in performing this type of work. The Contractor shall also furnish the manufacturer's specifications, literature, shop drawings for the layout of the concrete lining panels, and any recommendations, if applicable, that are specifically related to the project.
- B. Alternative fabric formed concrete lining materials may be considered. Such materials must be preapproved in writing by the Owner's Representative prior to the bid date. Alternative material packages must be submitted to the Owner's Representative a minimum of fifteen (15) days prior to the bid date.

Part 2 Products

2.01 General - Fabric Formed Concrete Lining

- A. Fabric formed concrete lining(s) shall be Uniform Section (US) type 8" UMNN or approved equal, and have a nominal average thickness of 8 inches.

Table 1.0
CAST-IN-PLACE PROPERTIES OF STYLE 8" UMNN

Physical Properties	Units	Value
Average Thickness (Nominal)	in	8.0
Cord Spacing		3" x 6"
Coverage per Cubic Yard Mortar	ft ²	38
Dry Weight	lb/ft ²	90

2.02 Fabric Forms

- A. The fabric forms for casting the concrete lining(s) shall be as specified, Fabriform® Unimat (as shown on Table 2) fabric forms from Construction Techniques, Inc, 15887 Snow Road, Cleveland, Ohio 44142, Tel: 216.267.7310; or approved equal. The fabric forms shall consist of woven double-layer, open selvage fabric joined in a mat configuration. Fabric shall be woven of 100% high-tenacity, continuous multifilament nylon of which a minimum of 50%, by weight, shall be textured fiber. The fabric shall conform to the properties required on Table 2.0. The fabric forms shall be free of defects or flaws which significantly affect their physical, mechanical, or hydraulic properties.

Table 2.0
PROPERTY REQUIREMENTS – CONCRETE EROSION CONTROL LINING SYSTEM FABRIC

	Test Method	Units	Minimum Values
Physical Properties			
Composition of Yarns			Nylon
Mass Per Unit Area (double-layer)	ASTM D 5261	oz/yd ² (g/m ²)	13(440)
Thickness	ASTM D 5199	mils (mm)	30 (0.76)
Mechanical Properties			
Wide-Width Strip Tensile Strength	ASTM D 4595		
Warp		lbf/in (kN/m)	300 (52.5)
Fill		lbf/in (kN/m)	200 (35)
Elongation at Break	ASTM D 4595		
Warp		%	15
Fill		%	20
Grab Tensile Strength	ASTM D 4632		
Warp		lbf (N)	400 (1780)
Fill		lbf (N)	250 (1110)
Grab Tensile Elongation	ASTM D 4632		
Warp		%	30
Fill		%	30
Trapezoidal Tear Strength	ASTM D 4533		
Warp		lbs (N)	175 (775)
Fill		lbs (N)	150 (665)
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Standard Sieve (mm)	40 (0.425)
Flow Rate	ASTM D 4491	gal/min/ft ² (l/min/m ²)	90 (3665)

- B. Fabric forms shall be woven with nylon spacer cords to provide points of attachment on specific centers. The spacer cords shall serve to control the thickness of the revetment without bursting the fabric during the fine aggregate injection.
- C. The fabric forms shall be factory sewn, by joining the together top layer to top layer and bottom layer to bottom layer, into predetermined custom sized panels. All factory sewn seam shall be downward facing. Factory sewn seams and zipper attachments shall be made using a double-needled machine utilizing a Standard Type 401 stitch. A single seam in which all four layers of fabric are joined at one point will not be permitted.
- D. The Contractor shall submit the fabric form manufacturer's certificate that the supplied fabric forms meet the criteria of these Specifications, as measured in full accordance with the test methods and standards referenced herein. The certificates shall include the following information about each fabric form delivered:

Manufacturer's name and current address;

Full product name;

Style and product code number;
Form number(s);
Composition of yarns; and
Manufacturer's certification statement.

2.03 Fine Aggregate Concrete

- A. Fine aggregate concrete shall consist of a proportioned mixture of Portland cement, fine aggregate (sand) and water mixed to provide a readily flowable grout. The mix shall exhibit a compressive strength of 2,500 lb/in² (17 MPa) at 28 days, when made and tested in accordance with ASTM C 31 and C 39.
- B. At the direction of the Owner's Representative, the Contractor shall demonstrate the suitability of the fine aggregate concrete mix design by pumping the proposed fine aggregate concrete into 5 ½" (140 mm) diameter sleeves. The sleeves shall be constructed of a single layer of the same fabric as the forms. Test cylinders, 12" (300 mm) long, shall be cut from each specimen and tested in accordance with ASTM C 39. The test shall be performed at the start of the project unless directed by the engineer. The average compressive strength of the fabric cast cylinders shall be at least 20 percent higher at 7 days than that of the companion test cylinders made in accordance with ASTM C 31, and not less than 3,000 psi (21 MPa) at 28 days.
- C. If required, bulkheads (grout stops) may be installed parallel to and in between individual mill widths at predetermined intervals to regulate the flow of fine aggregate concrete. Grout stops shall be designed as to produce full mat thickness along the full length of the grout stop.
- D. Water for mixing shall be clean and free from injurious amounts of oil, acid, salt, alkali, organic matter or other deleterious substances.
- E. Admixtures and/or pozzolan may be used with the approval of the Owner's Engineer. Use of superplasticizers requires special precautions. Use of silica fume is not recommended. Pozzolan, if used, shall conform to ASTM C 618, Class C, F, or N.

Part 3 Execution

3.01 Installation

- A. The fabric forms shall be stored in a clean, dry area where it will not be subject to mechanical damage or exposure to moisture or direct sunlight. Fabric shall be kept dry prior to installation.
- B. Areas on which fabric formed concrete lining are to be installed shall be constructed to the lines, grades, contours, and dimensions shown on the Contract Drawings. The areas shall be free of all obstructions and organic material such as projecting stones and roots. Where required by the Owner's Representative, soft and otherwise unsuitable subgrade soils shall be identified, excavated, and replaced with select materials in accordance with Section 02200 Earthwork. Where such areas are below the allowable grades, they shall be brought to grade by placing compacted layers in accordance with Section 02200 Earthwork.
- C. Excavation and preparation of anchor, flank and toe trenches or toe aprons shall be done in accordance with the lines, grades, contours, and dimensions shown on the Contract Drawings.

- D. Immediately prior to placing the fabric forms, the prepared area shall be inspected by the Owner's Engineer, and no forms shall be placed thereon until the area has been approved.

3.02 Fabric Form Placement

- A. Fabric panels shall be positioned, as specified by the Engineer, at their approximate design location. Adjacent fabric form panels shall be joined in the field by means of sewing or zipping closures. Adjacent panels shall be joined top layers to top layer and bottom layer to bottom. All sewn seams shall be downward facing. When placing panels an allowance for approximately 4 percent contraction of the form in each direction which will occur as a result of fine aggregate concrete filling.
- B. When conventional joining of fabric forms is impractical or where called for on the Drawings, adjacent forms may be overlapped a minimum of 3 feet (1 m) to form a lap joint, pending approval by the Owner's Representative. Based on the predominant flow direction, the downstream edge of the form shall overlap the upstream edge of the next form. In no case shall simple butt joints between forms be permitted. However, a modified butt joint where an underlayment of similar fabric is sewn to one panel and overlapped a minimum of 2 feet by the adjacent panel is allowed subject to approval by the Owner's Engineer.
- C. Immediately prior to filling with fine aggregate concrete, the assembled fabric forms shall be inspected by the Owner's Representative, and no fine aggregate concrete shall be pumped therein until the fabric placement and field seams have been approved. At no time shall the unfilled fabric forms be exposed to ultraviolet light (including direct sunlight) for a period exceeding 5 days.

3.03 Fine Aggregate Concrete Placement

- A. Following the placement of the fabric forms, fine aggregate concrete shall be pumped between the top and bottom layers of the fabric form through small slits be cut in the top layer of the fabric. These slits shall be of the minimum length to allow proper insertion of a filling pipe inserted at the end of the injection pipe. The injection pipe shall be wrapped tightly at the point of injection with a strip of burlap during pumping. First pump the upper edge of the mat which has been placed in the anchor trench followed by injection into the lower edge, working back up the slope. Avoid over-pressuring of the fabric. After pumping, the burlap shall be pushed into the slit as the injection pipe is withdrawn in order to minimize spillage of grout on the revetment surface. The burlap seal shall be removed prior to the final set of the fine aggregate concrete and the injection area hand-finished. The sequence of grout injection shall be such as to ensure complete filling of the revetment forming fabric to the thickness specified by the fabric manufacturer.
- B. Fine aggregate concrete shall be pumped in such a manner that cold joints are avoided. A cold joint is defined as one in which the pumping of the fine aggregate concrete into a given form is discontinued or interrupted for an interval of 45 or more minutes.
- C. Prior to removing the filling pipe from the current concrete lining section and proceeding to the fine aggregate concrete filling of the adjacent lining section, the thickness of the current lining section shall be measured by inserting a length of stiff wire through the lining at several locations from the crest to the toe of the slope. Any mat measuring less than 90 percent of the average of all thickness measurements shall be re-injected until desired average thickness has been attained.

- D. Foot traffic will not be permitted on the freshly pumped concrete lining when such traffic will cause permanent indentations in the lining surface. Walk boards shall be used where necessary.
- E. Excessive fine aggregate concrete that has inadvertently spilled on the concrete lining surface shall be removed with a broom and shovel. The use of a water hose to remove spilled fine aggregate concrete from the surface of the freshly pumped concrete lining shall not be permitted.
- F. After the fine aggregate concrete has set, all anchor, flank and toe trenches shall be backfilled and compacted, as specified by the Owner's Representative.

-End of Section-